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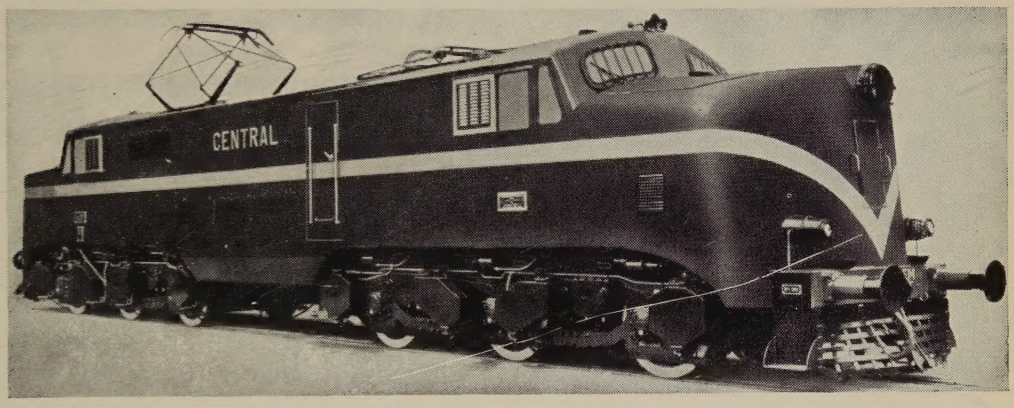

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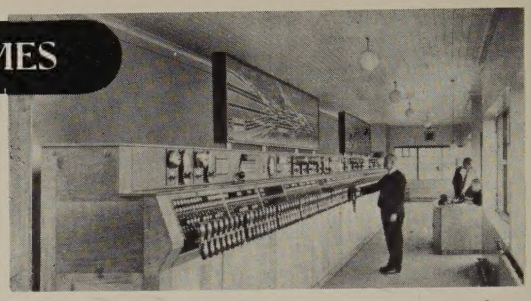
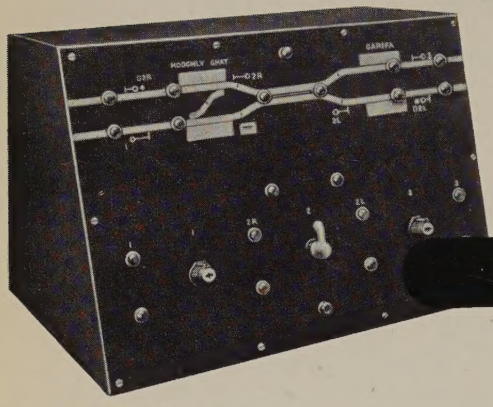


Bristol West Cabin—British Railways, Western Region, 328 levers



Panel at Hooghly Ghat, India

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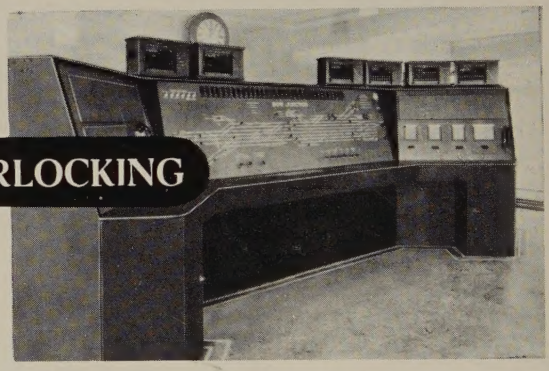

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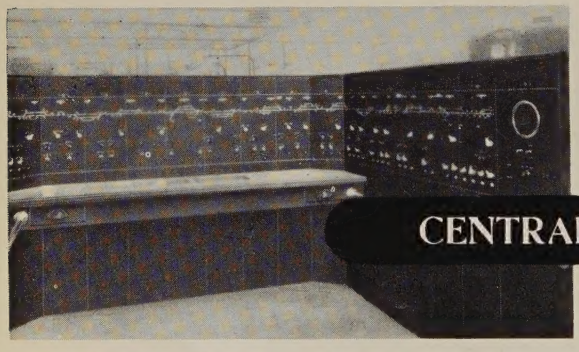

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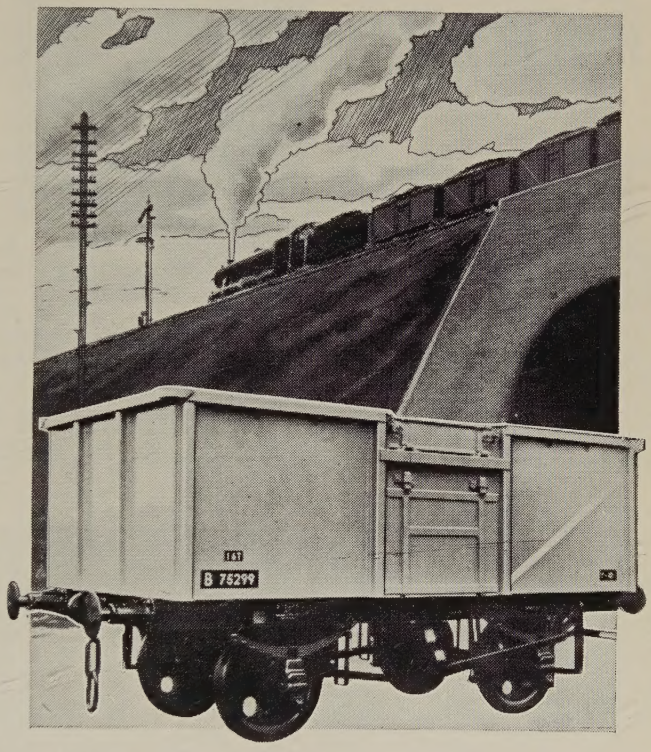

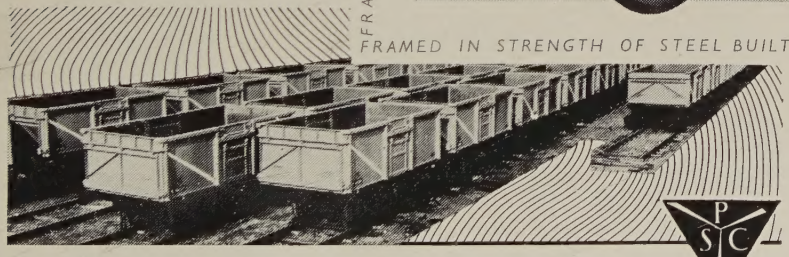

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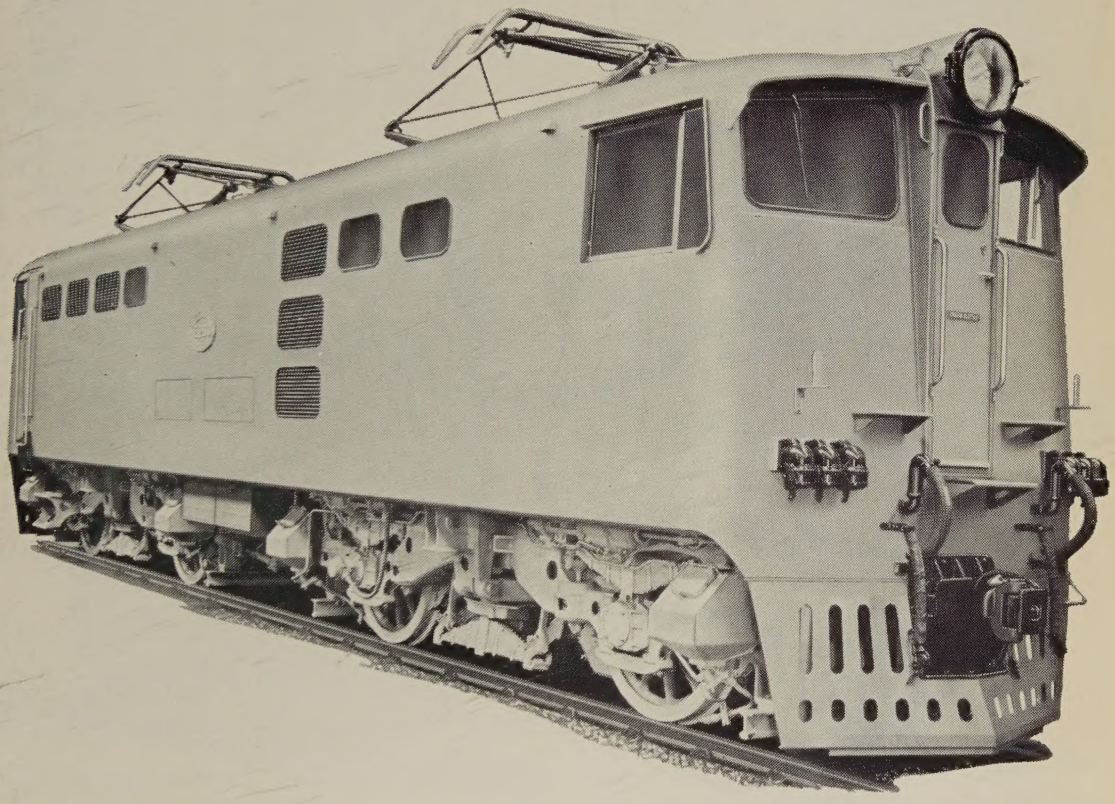

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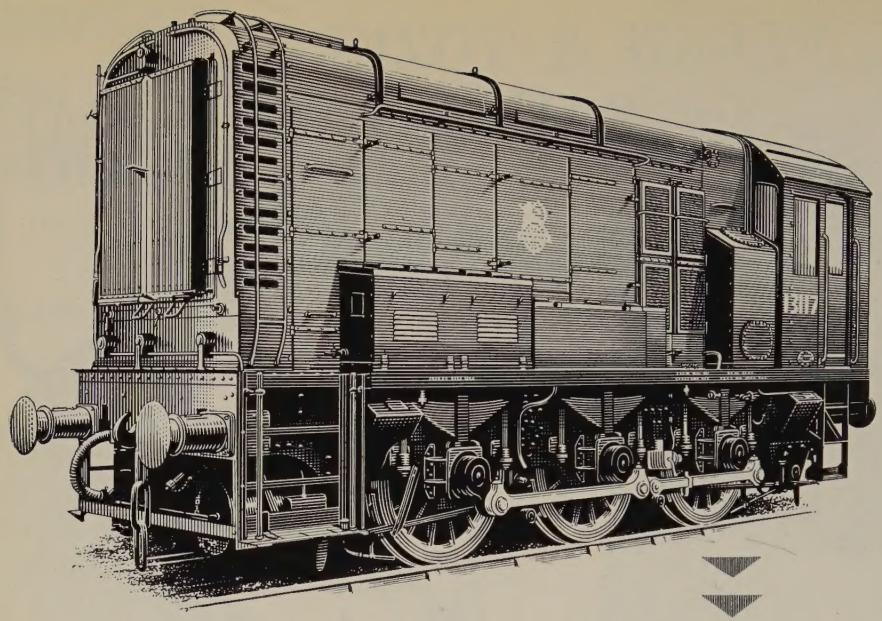

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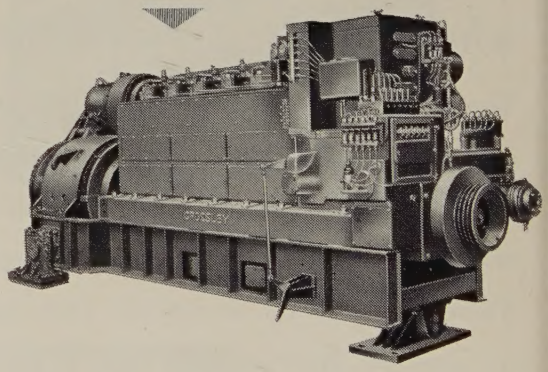

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OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

(ENGLISH EDITION)

PUBLISHING and EDITORIAL OFFICES : 19, RUE DU BEAU-SITE, BRUSSELS

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Advertisements : All communications should be addressed to the Association, **19, rue du Beau-Site, Brussels.**

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Vol. XXXIII. — No. 8. August 1956.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[625 .233 (493)]

Empirical determination of the best positive electrode of a storage battery for train lighting,

by E. MEYER,
Ingénieur principal à la Société Nationale des Chemins de fer belges.

1. Importance of the question.

Several thousand vehicles of the Belgian National Railways Company are still equipped with lead storage batteries. Their replacement by alkaline batteries would be desirable, but owing to the high expenditure involved, this work has had to be deferred.

The storage batteries consist of cells of 180 or 110 ampere-hours capacity, assembled in boxes with 8 or 12 cells so as to produce the rated voltages of 16 or 24 volts.

Merely as a reminder, we may mention the batteries of the enclosed type with which this exposition is not concerned.

The classical lead storage batteries consist of positive electrodes with natural formation and negative electrodes with rapid formation.

The electrodes are identified by :

a) the manufacturer's trade mark;

b) the date on which the guarantee expires, i.e. 18 months after the date of supply.

When a damaged battery is withdrawn from service or during the annual inspection of the batteries, those electrodes beyond repair are replaced.

The main purpose of the annual inspection is the washing of the electrodes and containers so as to avoid the formation of a bridge of sediments between two electrodes of different polarity which rapidly leads to the destruction of the electrode.

The electrodes used as replacements are supplied in response to tenders and must :

a) conform to the prescribed dimensions;

b) undergo a capacity test;

c) carry an absolute guarantee for 18 months.

There is no point in dwelling at length on the somewhat factitious character of these specifications.

It would be comparatively easy to insist on a longer guarantee, e.g. for 50 or 80 months but the gain thus obtainable would be obtained by the heavy and costly strain on clerical work imposed on an administration already too easily tempted to insist on detailed statistics.

For the following reasons, no use is made of accelerated ageing or load cycle tests providing for a series of accelerated, consecutive charging and discharging

operations on one or several sample batteries :

a) This test would, necessarily and unfortunately, have to be based on a small number of batteries. Would it not be risky to rely on the results of a few measurements in eliminating or favouring one particular electrode manufacturer ?

b) This test would take a long time, though obviously not as long as the actual life of a battery for train lighting. On the basis of a daily cycle of charging and discharging operations, the test would have to extend over a period of one year which would also make the test very expensive.

c) This test does not correspond to the stresses to which the batteries are subjected in practice.

The train lighting battery is not subjected to full cycles of charging and discharging but to a series of repeated partial charging and discharging operations, followed by recuperating periods and a new series of charging and discharging operations. Moreover, the mechanical stresses are not negligible.

For the sake of comprehensiveness, we might also mention the chemical stresses due to the ingress of dust, especially those fine cast iron and iron filings produced by the reciprocal wear of brake shoes and tyres.

Every year several thousands of positive electrodes are replaced, and come into the category of used electrodes, shrivelled and extended beyond the permissible limits.

As the electrode manufacturers have little difficulty in complying with the specifications, the official entrusted with the examination of the offers received in response to an invitation for tenders would be tempted, for administrative reasons, to award the order to the lowest bidder.

This course will set his administrative mind at rest, but will in all probability not ensure the reliability of the train lighting service.

2. Determination of the best electrode by statistical means.

Since the previous orders had been awarded to two suppliers whom we shall call A and B to avoid any susceptibilities as the firms concerned are Belgian, it appeared possible to deduce from the presence of these tens of thousands electrodes in different conditions of wear a simple statistical method for the choice of the best electrode.

No deductions could be made from a successive examination of the orders because, at the time of the liberation, tens of thousands of electrodes had been acquired in order to replace those worn out during the war which could not then be replaced as lead was a metal of high strategic value.

The new electrodes were supplied during the years 1946 to 1950. The date on which the guarantee period expires is stamped on them at the time of delivery. A single contract usually covers several partial deliveries.

Finally, it was only about 1951 that it became possible to complete the rehabilitation of a great number of vehicles which had suffered damage during the war, and this gave rise to supplementary orders of electrodes.

It was therefore impossible to arrive at reliable conclusions as to the value of

electrodes supplied by different suppliers on the basis of the frequency of the orders.

The systematic annual washing of the batteries, on the other hand, furnishes a wealth of information which need only be judiciously exploited.

Each battery repair shop was asked to keep records of the electrodes withdrawn from service, and to record, on a monthly return, the name of the supplier, the expiry date of the guarantee, and the date on which the battery was withdrawn from service.

One thus obtains a monthly return of the following form :

Number of electrodes withdrawn from service after a maximum period of : (in months)	*Number of electrodes supplied by*	
	Supplier A	*Supplier B*
20	0	1
21	0	1
.	.	.
.	.	.
50	1	1
51	2	2
.	.	.
.	.	.
65	3	1
.	.	.
80	.	no electrode exceeding 87 months
87	.	
150	1	

These tables can be made much more telling by calculating the total number of electrodes of each supplier, withdrawn from service, and relating to this number, the number of electrodes which have been in service for a minimum time of x months.

With these figures, it is possible to plot, for each supplier and each month, a characteristic curve indicative of the quality of the electrodes (fig. 1).

The abscissa of the diagram is the time in months whilst the ordinate shows the percentage of electrodes having exceeded the life corresponding to the abscissa.

If one of the curves completely envelops the other, the former indicates a higher quality of electrodes. The area contained between the reference axes and the curve is a direct measure of the quality of the electrode.

These statistics, compiled month by month by each workshop, have shown consistent results throughout. This was necessary to avoid the justified reproach that a law has been deduced from a series of unfortunate exceptional cases.

Thus, all the relevant factors have indirectly been taken into account : the quality of the electrolyte, the care taken in carrying out maintenance work, the difference in chemical, physical (frost, heat) or mechanical stresses; for, all these electrodes are taken into service without any regard to their origin.

The sections included hundreds of electrodes supplied by the two suppliers and revealed an average service life of 100 months for electrodes of origin A, and of 75 months for electrodes of origin B.

3. Savings effected.

In the latest tenders, the electrodes offered by B were 1 per cent cheaper than those offered by A. If the administrative rules had been followed indiscriminately, this important order covering the supply of electrodes for a whole year would have been awarded to B.

But the calculation of the service life of the electrodes had revealed the economic advantage of awarding the order to his competitor who did, in fact, get the order.

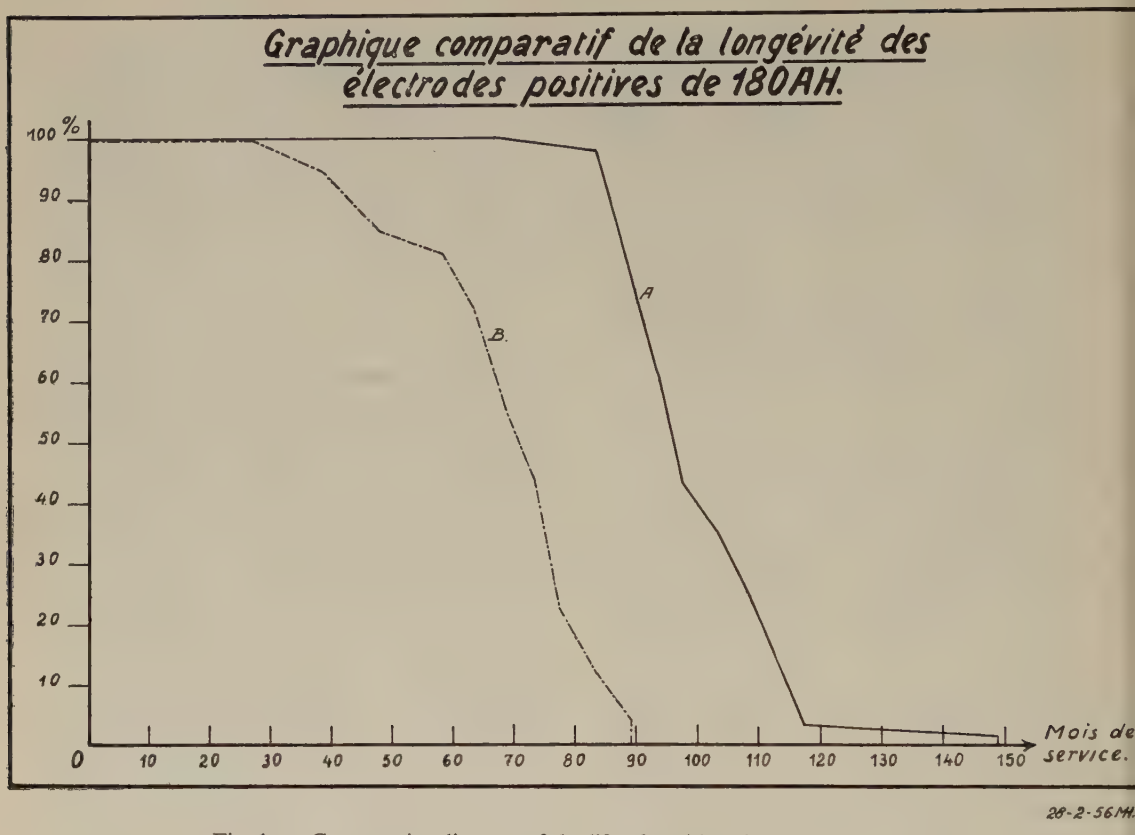


Fig. 1. — Comparative diagram of the life of positive electrodes of 180 Ah.
Mois de service = number of months in service.

As the price of a positive electrode of 180 ampere-hours is about 500 Belgian Francs, whilst the average service life of the electrodes is 100 and 75 months, respectively, the savings effected on an annual consumption of 3 000 electrodes amount to

$$12\left[\frac{3\,000 \times 500}{75} - \frac{3\,000 \times 500}{100}\right] = 60\,000 \text{ fr.}$$

To these direct savings on materials must be added the indirect savings due to the reduction in the number of train lighting failures, and the greater reliability of the train service which entails a real, if hardly quantifiable, saving in staff costs.

Although the subject of this exposition may seem trivial from a railway point of view, it may serve to bring home the fact that statistical methods, judiciously applied, always yield interesting results provided that the number of items concerned is sufficiently great for the law of large numbers to come into play.

[625 .162 (43) & 656 .254 (43)]

Protection of level crossings on the Deutsche Bundesbahn,

by Heinrich KORNER, Dipl.-Eng.

Hauptverwaltungsrat, Deutsche Bundesbahn, Francfort s/Main.

I. Introduction.

During recent years, more and more attention has been focused on level crossings between railways and roads, and more particularly upon their protection. This increasing interest in the question is undoubtedly due to the considerable increase in motor traffic and the great number of road accidents. Although accidents at level crossings are only a very small proportion of road accidents, it must be recognised that these are precisely the accidents which are reported in much detail in the press, on the wireless and by the public, probably on account of the tragic circumstances which often accompany them and their serious consequences. This same state of affairs can also be noted in other countries.

The steps taken in different countries to protect level crossings and prevent accidents have varied considerably. The standardisation of the protection of level crossings is undoubtedly on the agenda of the various international organisations such as the Interior Transport Committee of the European Economic Commission (E.E.C.), the International Railway Congress Association (I.R.C.A.) (*) and the International Railway Union (I.R.U.), but up to date, only particularly urgent problems have been dealt with and certain methods of protection. It therefore appears interesting and instructive to learn the safety measures taken in various countries.

The object of the present study is to review the steps taken to protect level crossings on the Deutsche Bundesbahn (DB) at the present time (**). As far as possible we will also give certain comparative figures relating to other countries.

Conditions obtaining in the territory covered by the German Federal Republic appear to be of particular interest, in view of the great increase in the number of motor vehicles in circulation in the country in the last few years, compared with other countries (Table 1).

We will consider in turn :

— The Deutsche Bundesbahn level crossings on the railway and road networks;

(*) Enlarged meeting of the Permanent Commission at Stockholm, June 9th to 11th 1952.

(**) We will refer to the series of articles called *Die Sicherheit am Bahnübergang* (Safety at level crossings), which appeared in Nos 10, 11 and 12 of the review *Eisenbahntechnische Rundschau* (ETR) and Nos. 20, 21, 22 and 23, 1955, of the official publication *Die Bundesbahn*. These publications give a complete report of the protection of level crossings on German federal territory. In the meantime, they have been republished in a special issue of the ETR.

TABLE 1. — **Increase in the number of motor vehicles between 1950 and 1954.**

Country	No. of motor vehicles (*)		
	1950	1954	Increase
	in thousands		%
German Federal Republic	1 950	4 097(1)	110
Great Britain	4 414	5 130	16
Holland	318	446	40
Switzerland	265	484	83
United States of America	48 633	59 468	22

(*) According to « *Statistische Berichte* » published by the Wiesbaden Federal Office of Statistics, dated the 22nd June 1955.

(1) Vehicles in circulation on the 1st July 1954, not including those belonging to the Army of occupation.

— The laws and regulations concerning the protection of level crossings;
— Existing methods of protection;
— Accidents at level crossings;
— Steps to be taken to improve the safety of level crossings.

II. Level crossings on the railway and road networks.

The length of railway lines operated by the Bundesbahn is 30 612 km (19 021 miles) and the classified roads in the federal territory include about 24 200 km (15 036 miles) of federal roads, 50 700 km (31 503 miles) of first class roads and 50 900 km (31 628 miles) of second class roads. On the railway network (main and secondary lines) there are about 40 000 level crossings (see Table 2). On the average, the railway line crosses a road, a country lane, a woodland track or a private road about every 7 to 800 m (765 to 875 yards), though there is only one level crossing on the Deutsche Bundesbahn about every 22 km (13.67 miles) of federal roads, 24 km (15 miles) of first class roads and 21 km (13 miles) of second class roads.

Out of the total of approximately 40 000 level crossings on the Deutsche Bundesbahn, there is some form of technical protection at about 18 300 (gates or winking lights worked by the trains) and no form of technical protection at about 21 700. i.e. these latter are only protected by the road signs, the visibility and acoustic signals (*). Table 3 gives

(*) As it is necessary to protect all level crossings, even those where there are no gates or winking lights, on the DB a distinction is made between « level crossings with technical protection » — those equipped with gates and winking lights — and « level crossings without technical protection » — i.e. those which are not so equipped.

TABLE 2. — **Length of lines in operation and number of level crossings on the DB and other railways in German Federal Republic territory.**

Type of line	Length in operation km	No. of level crossings	I.e. one level crossing per ... km
Main lines (single, and double or several tracks) . .	18 412	15 088	1.23
Secondary lines (single or double track)	12 200	24 790	0.49
Total DB	30 612	39 878	0.77
For comparison : other railways in the German Federal Republic	6 000	14 350	0.42

TABLE 3. — **Length of system in operation and number of level crossings of certain other European Administrations.**

1	2	3	4	5	6	7	8
Railway Administration	Length of lines km	Level crossings					i.e. one level crossing per km
		Total No.	without gates or winking lights	without gates or winking % of col. 3	with gates or winking lights	with gates or winking % of col. 3	
DB (German Federal Republic (*)	30 612	39 878	21 633	55	18 245	45	0.77
SNCB (Belgium)	4 985	5 204	2 800	54	2 404	46	0.96
DSB (Denmark)	2 642	5 149	4 264	83	885	17	0.51
SNCF (France)	41 440	36 831	15 794	42	21 033	58	1.12
BR (Great Britain) . . .	31 055	27 050	370	1	26 680	99	1.15
FS (Italy)	16 818	17 259	1 783	10	15 476	90	0.98
NS (Holland)	3 210	3 391	2 256	67	1 068	31	0.95
SJ (Sweden)	15 173	6 151	2 320	38	3 645	59	2.44
CFF (Switzerland) . . .	2 927	4 994	3 186	64	1 808	36	0.58

(*) Position in 1954. The other figures relate to the end of 1952 and are mainly taken from the statistics of the IRU (U.I.C.).

for the sake of comparison corresponding information for certain European Railways, and shows that the great number of level crossings on the Deutsche Bundesbahn has no counterpart on any other European railway. However, if the number of level crossings is related to the mileage of the railway lines, it will be seen that there are rather more in proportion in Denmark, Switzerland, Austria (0.54), Norway (0.45) and Finland (0.66).

The great number of level crossings and the greatly increasing motor traffic has given rise to particularly serious problems in the case of the Deutsche Bundesbahn and led to considerable expense in maintaining and improving safety standards.

III. Laws and regulations.

The protection to be given level crossings by the DB and by the authority of the road police, as well as the behaviour laid down for road users and railway staff at level crossings are contained in the following laws and decrees :

1. Regulations for the construction and operating of railways (BO), 1943 edition;

2. Regulations on railway signals (ESO), 1942 edition;

3. Decree on the behaviour laid down for road traffic (Highway Code, St. VO) of the 24th August 1953;

4. Decree on the licensing of motor cars and lorries for road traffic (Decree on the licensing of road traffic, St. VZO), of the 24th August 1953;

5. Law on the crossing of railway lines and roads, of the 4th July 1939;

In addition to these legal instruments, the DB also applies the following regulations :

6. Regulations of the Supervision Services of the railway (Bewa V);

7. Regulation of the Traffic Department (FV);

8. Arrangements for carrying out the Regulations on Railway Signals (AB);

9 Principles governing the determination of the visibility at level crossings where there are no gates (RÜW);

10. Rules for setting up and maintaining the warning notices at level crossings (in the form of a St. Andrews cross) (Warnkreuzrichtlinien);

11. Instructions concerning the lighting of level crossings equipped with gates (Ri Bel Wü);

12. Regulations concerning the installation of level crossing gates.

The laws affecting road traffic are completed by :

13. Service instructions governing the highway code (St. VO) and the decree on traffic (St. VZO), mentioned under 3 and 4 above.

Regulations concerning the construction and operation of railways (BO) :

The Regulations on the construction and operation of railways, mentioned under 1 above, contain detailed legal prescriptions concerning the protection of level crossings in paragraphs 18, 46 and 79. These apply to all public rail-

TABLE 4. — **Legal protective measures according to the Regulations for the construction and operating of railways (BO).**

Type of line	Method of protection of level crossings	
	little used	much used
Main line	Gates or winking lights	
Secondary line (Max. speed ⩽ 60 km/h) *a*) good visibility at level crossing	Bell and whistle	Gate or winking light or Speed/train ⩽ 15 km/h and bell and whistle.
b) poor visibility at level crossing	Minimum visibility of the line from the St. Andrews cross ⩽ 50 m. Acoustical signals of the train (bell, whistle). Reduced visibility, speed/train ⩽ 15 km/h or crossing keeper	Gate or winking light

way systems. From the point of view of the method of protection, first of all a distinction is made between the types of line : the main lines are those with heavy traffic and high speeds, and the secondary lines, those of lesser importance, where the speed does not exceed 60 km (37 miles)/h. In paragraphs 18 and 46, it is laid down that gates or winking lights must be provided at all level crossings on the main lines (these two methods of protection are considered as equally good by the BO), in other words, technical protection, whereas on the secondary lines, the method of protection varies according to whether the level crossing is :

a) much or little used, and

b) the visibility is good or poor.

Table 4 shows how and when level crossings must be protected according to these regulations on the construction and operation of railways.

The supervising authorities are responsible for deciding the traffic figures and visibility. In order to get uniform interpretation of these, the former Deutsche Reichsbahn just before the second world war published amongst its own regulations « Principles to estimate the visibility at level crossings without gates » (RÜW, No. 9 above). According to these, a level crossing is to be considered as one with heavy traffic when the road traffic is such that the road users can no longer pay sufficient attention to the railway line. The idea of « visibility » is determined in these regulations by fixing areas of vision, the size of which depends upon the speed and length of the road vehicles using the crossing as well as the maximum train speeds.

These areas are bounded by the road and the centre line of the railway, as well as by a straight line joining two points situated respectively on the road and on the railway; they must be kept free of all obstacles to vision at all times. We will return to this point and deal more thoroughly with the determination of these areas in our next chapter.

The other legal clauses of the BO cover details about the different ways the gates are serviced, as well as their technical equipment, as well as the protection of level crossings on private railways and over footpaths for pedestrians; they also include certain relaxations allowed, signs giving warning of level crossings and cases in which the acoustical signals must be sounded before approaching the crossing (bells and whistles) (paragraphs 18 and 58). Paragraph 79 of the BO Regulations contains the clauses on crossing the track addressed to road users and paragraph 49 lays down in connection with the lighting of level crossings : « Public level crossings that are much used must be lighted whilst the gates are shut. »

Regulations on railway signals (ESO) :

This document contains the regulations regarding announcing and signalling level crossings along the permanent way, as well as information about the giving of signals by bell or whistle by motor vehicles to warn road users. These regulations are therefore intended for the railway operating staff, especially the drivers of locomotives.

Decree on the behaviour of road traffic (St. VO) :

Whereas the BO has always contained the laws regarding the protection of level crossings and traffic over them, the highway code (St. VO) which is the fundamental regulation of road traffic, and is much more widely known than the purely railway regulations (BO), until 1953, as regards the behaviour of road users at level crossings, merely reminded them that it was necessary to drive with the same care as in general traffic, and referred them to the regulations contained in other decrees (for example the BO). Owing to the very great increase in road traffic, in the new issue of the highway code dated the 24th August 1953, it was found necessary to fill in this gap and devote a new paragraph 3 *a* to the principles of the behaviour of road users at level crossings.

The St. VO bases the regulations affecting traffic at level crossings on the « priority » laid down in the BO of railway traffic over road traffic. This idea does not merely mean priority in crossing; it also takes into account the longer braking distance required in the case of railway vehicles, due to physical conditions; they cannot in fact, particularly in the case of heavily loaded trains, deviate from their course.

To give the reader some idea of the regulations contained in the highway code (St. VO), we give below some of the more important of these :

« When approaching and using level crossings, special care must be taken in every case », i.e. whether the gates are open or closed. This general principle is completed to some extent by a series of more detailed regulations, such as :

« The driver of the motor vehicle must so regulate his speed of running as

to be able at any moment to meet all the obligations he has towards the traffic and to be able to stop his vehicle in good time if necessary. *This is particularly the case at places where the visibility is poor, such as at level crossings.* »

« It is forbidden to park vehicles... either side of railway level crossings, if the visibility of the railway line and protective devices is thereby reduced. »

« When stopping in front of a level crossing, lights should always be dimmed. »

« Level crossings must not be crossed if :

a) a railway vehicle is approaching;

b) the winking lights or other optical or acoustic signals give warning of the approach of a railway vehicle;

c) the acoustic signals announce the closing of the gates;

d) the gates are being closed of closed, or

e) the fact that road vehicles must not run over the level crossing is shown in some other way. »

Unfortunately, the decree does not impose a general ban on overtaking at level crossings. There is merely the clause :

> « It is forbidden to overtake at places where the visibility is poor », which makes it possible to erect in some cases signs forbidding overtaking at level crossings. »

The warning cross (St. Andrews cross) and other road signals giving warning of level crossings are given in the Highway Code in conformity with the « International Protocol on road traffic signs. »

As regards the St. Andrews Cross (fig. 14), it is stated :

> « The priority of public railways, justified in the Regulations on the construction and operation of railways, is shown by setting up the St. Andrews Cross »;

and as regards the warning notices (fig. 12 and 13) :

> « Warning signs must always be set up at crossings between roads open to general motor traffic and the railway lines with their priority. »

Decree on the licensing of motor cars and lorries for the road (St. VZO) :

This decree contains the details and regulations concerning the licensing and control of vehicles on the road. For example, the total length of motor vehicles with trailers must not exceed 20 m and their width 2.5 m. The maximum loads allowed are 10 tons per axle and 40 tons for road trains (*). In addition, the braking power of motor vehicles must be at least 2.5 m/sec.^{2} and if their maximum speed does not exceed 20 km (12 miles)/h, at least 1.5 m/sec.^{2}.

Law on crossings between railway lines and roads :

This law covers all public railway crossings (including connecting lines) with public roads and highways which, by reason of their nature, are capable of being used by public motor traffic. It deals with the making and alteration of the crossings, as well as the regulations regarding the costs thereby entail-

(*) A reduction of these loads and lengths is at present under consideration.

ed. Later on, we will go into further details about this law, because, unlike the case in most other countries, it imposes an extremely heavy financial burden on the German railways. It lays down that all the modifications and

remembered that during the last few years the railway traffic has not increased to any great extent, whilst road traffic has become three times as great since 1949, it seems very doubtful whether the essential reasons for any modifications

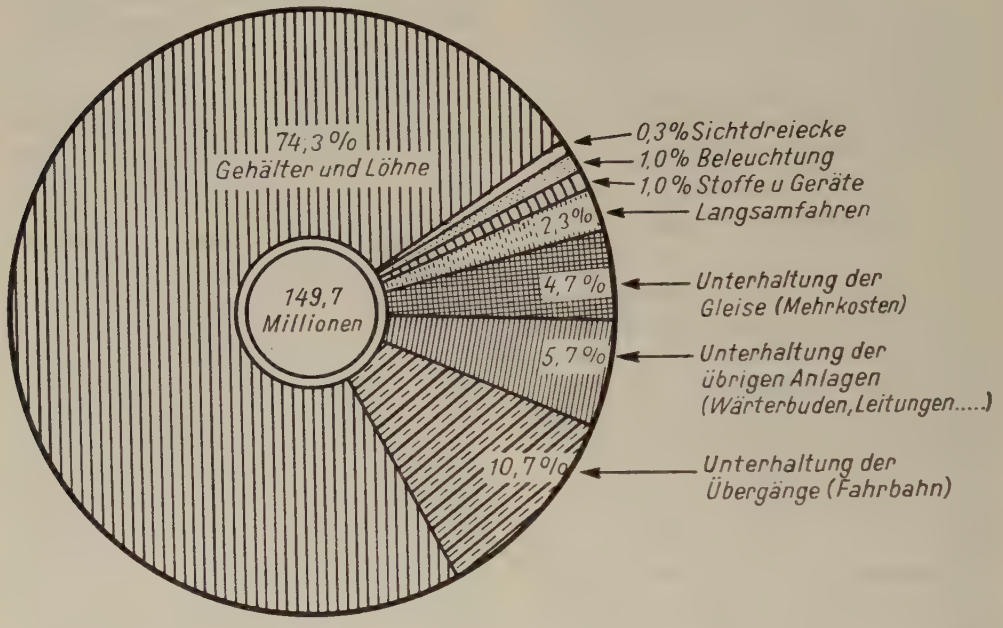


Fig. 1. — Cost to the DB of protecting level crossings in 1954.

Legend :

0.3 % Triangles of visibility.
1.0 % Lighting.
1.0 % Materials and equipment.
2.3 % Speed restrictions.
4.7 % Maintenance of the track (additional cost).
5.7 % Maintenance of other installations (keepers lookouts, communication lines...).
10.7 % Maintenance of level crossings (pathways).
74.3 % Wages and salaries.

improvements to existing crossings made necessary by the *crossing of the traffic* must be borne by the railway undertaking and by the organisation financially responsible for making the road. This rule applies without it being taken into account whether the railway caused the modification in question or whether it derives any benefit from it. If it is

and improvements needed, sometimes very urgently, at level crossings, or doing away with such crossings, are not due to the railway but rather attributable to a great extent to the road traffic. It seems therefore completely unjustifiable to ask the railway to support half the cost. This unjust aspect of the law on crossings becomes even more apparent

when it is remembered that the DB has always paid the whole cost of the services and maintenance for the protection of level crossings. The annual costs are shown, itemised, in fig. 1. In 1954, they amounted to about 150 million DM, i.e. nearly 3 % of the whole Deutsche Bundesbahn budget. It would be only fair if these costs also were divided up. The more road traffic increases, the more the law on crossings is seen to be one sided for the railway and advantageous for the road. For this reason the DB is trying to get this law altered, for example so that the cost of altering level crossings would be borne by those for whom the alteration was made, the other if necessary paying its share for any advantage it obtains therefrom (*). And the so-called cost of protection would be divided up more or less equally.

The supplementary clauses of the railway regulations listed under Nos. 6 to 12 will be dealt with, as far as this appears to be necessary, in the next chapter, when describing protective devices.

Fig. 2. — Locally operated gates.

IV. **Method of protecting level crossings.**

Gates :

Amongst level crossing gates we find : *gates normally kept open, operated at*

(*) This means, for example, that the DB when, owing to the increase in road traffic, a level crossing has to be replaced by a bridge would share in the construction of the latter to the extent of the capital value of the annual savings it will reap from the suppression of the level crossing.

site or from a distance, gates normally kept closed (also operated at site or from a distance), *fixed barriers* (sliding or pivoting barriers closed by a key), for example at level crossings on private railways or *turnpikes* for pedestrians.

Fig. 3. — Gates lit up by reflector bands.

The *gates normally kept open and operated at site* (fig. 2) are, as this description implies, worked directly at the site by a keeper. The regulations about closing the gates are contained in the Regulations on the supervision of the track (II, item 6). As regards the moment at which the gates should be shut, this states : « The gates must be closed in good time before the arrival of a train, and opened after it has passed, unless they have to remain closed because of another train... etc. » The time at which the gates are closed is determined by the timetable for the line, which is in the hands of the keeper, observation of the line, and examination of the clock. Although the trains are announced from station to station by bell or telephone, the keeper must not rely on these, the warning given by bell being only an additional aid.

The gates are sited 3 m (9′10 $^{1}/_{8}$″) from the centre line of the track; when open, the bars are in a vertical position; when closed they are in a horizontal

position. The closed gate is generally 1 m (3′3 $^{3}/_{8}$″) high (Regulations on crossing gates). If necessary — a lot of pedestrians in the middle of towns or near schools — an additional barrier is hung from the bar. To improve the visibility of the gates — especially for motorists — on the DB, these are painted in alternate bands of red and white, each one metre long over the whole length of the rails and part of these is fitted with lines of reflectors. These are arranged above the bar and are very clear at night (fig. 3). The gates are still worked mechanically in most cases. However, the use of electric devices to operate them is becoming more and more usual.

The lighting is governed by the laws of the BO mentioned above. In addition the Deutsche Bundesbahn lays down : in its « Regulations on the lighting of level crossings equipped with gates » that during lighting up times at level crossings where there is a lot of traffic, the road surface must be lit up all the time and that the bars of the gates must be lit when they are closed. There is therefore a distinction between the level crossing lamps which light the crossing itself and are kept alight all the time trains are running, and the gate

Fig. 4. — Gates normally closed (Anrufschranke) with loudspeaker on both sides.

lamps which only light the gates when they are closing or closed. Owing to the danger of dazzling the railway services, in general all the lamps used throw their light downwards from the base of the lamp.

Gates operated from a distance are only allowed in the case of level crossings where there is not much traffic. For economic reasons, they are operated from a far off point where the gate keeper can deal at the same time with other work in connection with the operating or train services (such as operating gates worked at site, looking after the services, points, etc.). According to the BO such gates can only be used when a whole series of special conditions have been complied with. The crossing must be clearly visible from the place where the keeper is working. The gates must be fitted with a bell giving preliminary warning of the closing of the gate to road users. In addition, it must be possible to open them by hand at the site after which they will automatically fall back into the closed position, to prevent any road user from being trapped within them, and in addition, they must be fitted with a control bell which warns the keeper if they are opened.

Normally closed gates (Anrufschranken) are only opened, at the site or from a distance, on request. The user of the level crossing asks the keeper to open them by means of a bell. The keeper however can only open the gates after obtaining authorisation to do so from the nearest signal box or station. These gates are only used on level crossings of secondary importance, where there is very little traffic; they can only be installed when the local authority agrees. This restriction is due to the loss of time suffered by road users as a result.

In recent years, such gates have been greatly improved by fitting them with *two-way loud-speakers* (W.L. installation), as shown in fig. 4 and 5. This replaces the bells and in addition makes it possible for the road user and keeper to exchange all the information needed. As a result of being able to exchange information in this way as well as finding out if the level crossing is clear by listening or asking those concerned, the conditions as regards visibility need not be so stringent. In addition, thanks to the use of electrically operated gates, it is possible to install gates operated on request fairly long distances away, so

Fig. 5. — Normally closed gates with loud-speaker on both sides.

that several gates can be operated quickly and safely from a single central post, which is kept fully informed of all train movements. So far only trial installations of this sort have been set up, and because the visibility is not as good as that laid down by the law, these have to be specially approved by the Federal Minister of Transport at the present time.

Installations with winking lights worked by the train :

The second type of technical protection consists of *warning lights worked by the train* and the new type of *winking lights worked by the train* put into service on the DB in 1952 which is still only in the trial stage.

The first trials of installations with warning lights were made on the Reichsbahn in 1930. These installations having proved their worth in practice, since 1936 they have been considered as giving the same protection as gates.

Fig. 6. — Automatic winking lights (worked by the train).

Since 1952, only the new type of winking lights have been used on the DB (fig. 6) which when a train is approaching show a red winking light (60 flashes per minute), being out the rest

of the time. Two types are in service : winking lights for control signals intended to the drivers, and winking lights controlled at a distance. Their arrangement is shown in fig. 7. In the case of the first type a warning signal is sited

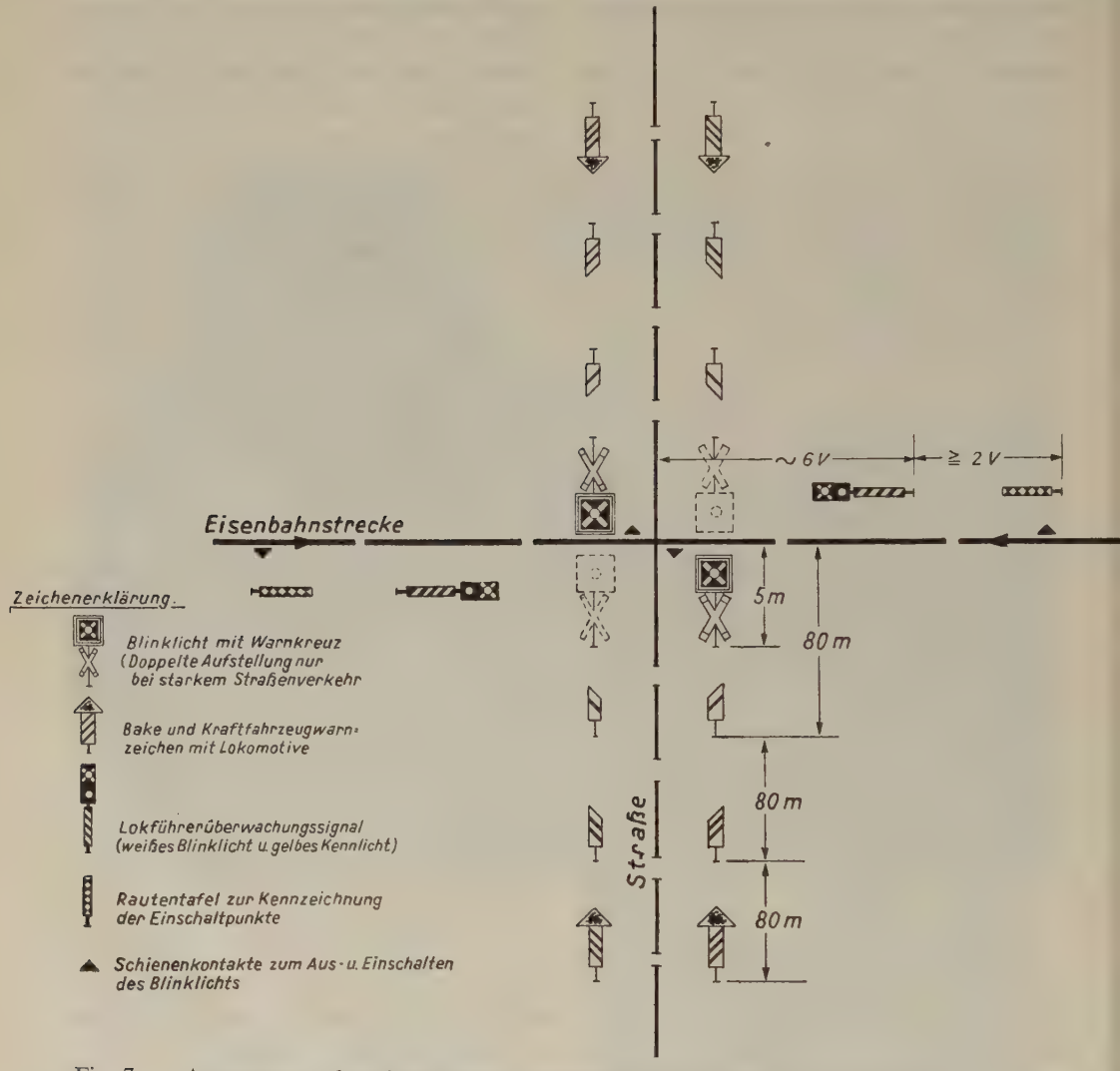


Fig. 7. — Arrangement of an installation of automatic winking lights with control signal worked by the driver.

Translation of German terms :

Eisenbahnstrecke = railway line. — Strasse = road. — Blinklicht mit Warnkreuz (Doppelte Aufstellung nur bei starkem Strassenverkehr) = winking signal with warning cross (double device only in the case of heavy road traffic). — Bake und Kraftfahrzeugwarnzeichen mit Lokomotive = warning post and signal for automobiles, showing a locomotive. — Lokführerüberwachungssignal (weisses Blinklicht u. gelbes Kennlicht) = control signal for the train driver (white winking light and yellow recorder light). — Rautentafel zur Kennzeichnung der Einschaltpunkte = chequered panel showing the circuit contact points. — Schienenkontakte zum Aus- u. Einschalten des Blinklichts = rail contacts putting the winking lights in and out of circuit.

at stopping distance in front of the level crossing (fig. 8) consisting of two signal lamps one above the other. The upper lamp is the actual light signal, which tells the driver if the installation is working as soon as he has cleared the contacts for the circuit. This shows a white winking light. The bottom lamp, using propane gas, marks the site of the control light; this always shows a fixed yellow light. With the second type, a control device at the nearest operating point (Betriebsstelle) shows that the equipment is working properly. If anything goes wrong, the driver is warned by the operating by means of a written note.

Fig. 8. — Control signal for the train driver.

The distant control device is fitted on the main lines, as with the high speeds run it is impossible to ask the driver to look out for still more signals. If anything goes wrong the driver must pass the level crossing on the alert at not more than 15 km (9.3 miles)/h, and blow his whistle.

The road signals of the winking light installations are generally sited on the right hand side of the road, and if the traffic is very heavy, on both sides of the road.

The new winking light installations have all given good results. At the present time, they are still considered as experimental and consequently in each case must be authorised by the Ministry of Transport before being installed. It is expected however that they will receive legal sanction within the near future.

As in several other European countries, and for many years in the United States, in 1954, the Deutsche Bundesbahn made a trial installation of *half-barriers operated by the train* (fig. 9). These half-barriers are connected with the new type winking light installations. As their name indicates, the arms only shut off the right hand half of the road, so that road vehicles can still clear the lines if the barriers are closed. The end

Fig. 9. — Automatic winking lights with half gates.

of the rails of the barrier is signalled to the road by red lights. The St. Andrew's Cross and the rails of the barrier can be painted with reflecting paint.

When the crossing is open, the road signal light is out and the barriers are raised up into the vertical position. When a train approaches, the red light winks for about 12 seconds to show that the barrier is going to be closed and for about 14 seconds after it has been closed. If anything goes wrong, it can be checked at a distance by the nearest operating post, and advised to the drivers.

Automatic gates should be installed above all on double lines to protect level crossings with very heavy traffic, replacing the manually operated gates. The trial installations made to date have given good results on the whole; it has however been found occasionally that certain road users (cyclists and motor cyclists) do not show the necessary attention and discipline, and try and get round the gates whilst or even after they have been closed.

Level crossings without gates or winking lights.

As we have already reported in Chapter III, level crossings without technical protection are only authorised in Germany on secondary lines, and only under certain given conditions. These conditions, as Table 4 shows, refer to the kind and amount of road traffic, good visibility of the railway line for the road user, as well as the speed of the trains when passing the level crossing. The protective measures to be taken include :

1. signs giving warning of level crossings erected at a level where they are easily seen by road users;

2. determining the area of visibility and keeping it permanently free of obstructions;

3. emission of acoustic signals by the trains; and

4. trains easily recognised at night.

The *signs and signals* used at level crossings will be described at the end of this chapter at the same time as the characteristics of level crossings having technical protection.

The *visibility* at a level crossing is assured, according to the « Principles for determining the visibility at level crossings » (RÜW) quoted in chapter III, when in each of the four sectors formed by the crossing of the centre line of the railway with that of the road, as fig. 10 shows, there is a triangle of visibility for fast and slow vehicles, so that road vehicles approaching the level crossing can see clearly all railway vehicles within the triangle of visibility. Points *a* and *b* on the centre line of the road are determined as follows :— the approach of a train should be visible at point *a* at the latest in the case of slow vehicle and at the latest at point *b* for fast road vehicles, so that they still have time to brake and stop before they get to the level crossing. Points *d* and *e* on the centre line of the railway are determined on the basis that the time the fastest train takes to run from the first or second of these points to the level crossing is longer than the time the fast or slow road vehicle takes to cross the danger zone, i.e. the distance between points *a* and *b* respectively plus the length of

the vehicle beyond the clearance of the level crossing. This is to make sure that any vehicle which arrives at the same time as a train within the triangle of visibility corresponding to its speed, whose driver has not time to draw up, can still cross over without danger.

v = 1.2 m/sec. and it was agreed that the distance corresponding to the braking distance and the time taken to react was 3 m, in other words, the point *a* was sited 3 m in front of the St. Andrews Cross. From the conditions laid down above for crossing the level crossing

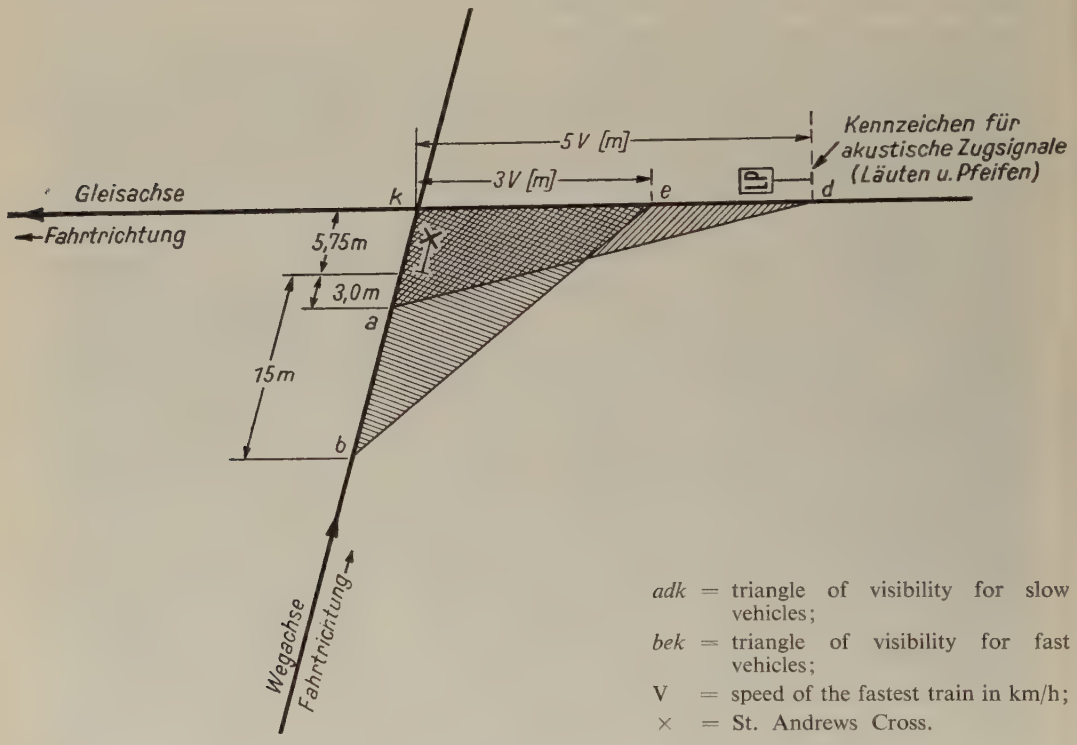


Fig. 10. — View of the line as assured by the triangles of visibility.

N. B. — Gleisachse = centre line of the track. — Wegachse = centre line of the road. — Fahrtrichtung = direction of running. — Kennzeichen für akustische Zugsignale (Läuten u. Pfeifen) = distinctive sign for acoustic signal given by the train (bell and whistle).

To determine points *a* and *b* certain stopping distances were assumed together with the time taken to react when the signal is sighted, and the braking power converted into the distance covered, in terms of the speed of the vehicle. In the case of slow moving road vehicles, walking pace was taken as the basis, i.e.

safely, in the case of a single track crossing, with a vehicle length of 7 m plus an added safety margin, the calculations give the distance from point *d* to the crossing as equal to 5 V (V km/h being the maximum speed authorised for the trains on the section).

Unfortunately, it was decided that the

maximum speed at which motor vehicles can cross a level crossing could not be laid down by law. The former Minister of Transport of the Reich merely agreed when the RÜW was drawn up that under normal local conditions point *b* should be 20 m (65′7 $^{3}/_{8}$″) in front of the nearest motor vehicles. In the case of a 20 m road unit (the longest road unit length now authorised on Federal territory) we get, by similar calculations to those made in the case of slow vehicles, a distance from the level crossing to point *e* on the centre line of the road equal to 3 V

Fig. 11. — New signal lights on the front of trains.

rail, in other words 15 m (49′2½″) in front of the St. Andrews Cross which is normally 5 m (16′5″) from the rail. In the case of motor vehicles, with a minimum braking rate from *b* of 2.5 m/sec^2 as laid down in Germany, together with a period of 1.5 sec. for reacting, the calculations give a speed of about 20 km (12.42 miles)/h. Consequently, according to the RÜW, the triangles of visibility are based on a speed of 20 km/h for the (V km/h = maximum speed authorised for trains on the section).

If speed limits are laid down for the trains at the level crossing, V must be taken as being equal to the average between the maximum authorised speed and the restricted speed. Under special conditions, for example a multi-track line, a crossing at a sharp angle between the centre lines of the railway and the road, on steep down gradients or pro-

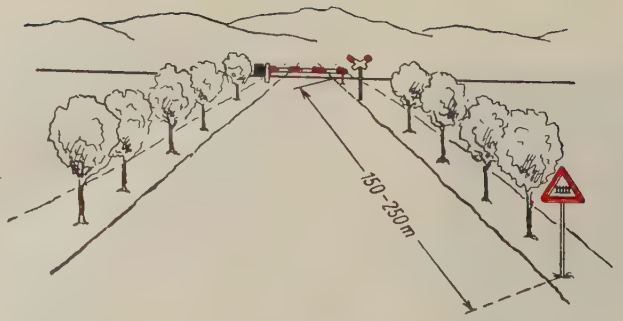


Fig. 12. — Sign showing a level crossing with gates with one or more lines (without warning boards).

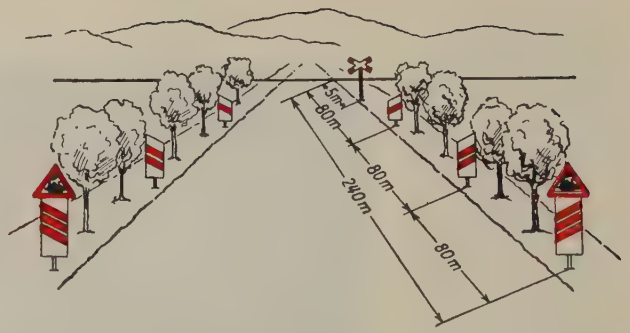


Fig. 13. — Sign showing a single track level crossing without gates (with warning boards).

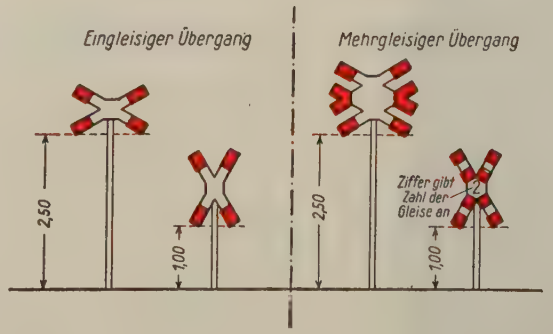


Fig. 14. — St. Andrews Cross in front of level crossings without gates.

N. B. — Eingleisiger Übergang = Single track level crossing. — Mehrgleisiger Übergang. — level crossing over several tracks. — Ziffer gibt Zahl der Gleise an = figure showing the number of tracks.

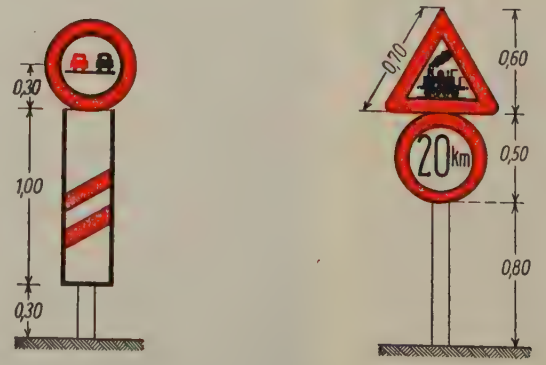


Fig. 15. — Signs showing that vehicles must not outrun, and the speed restrictions before level crossings.

nounced curves, appropriate additions must be made to the values of 3 V and 5 V. When the visibility of the line from the road does not correspond to these values and it is impossible to make it so at reasonable cost, the trains must run at a sufficiently reduced speed to fulfil the above conditions. The level crossing is then considered to meet the RÜW requirements from the point of view of visibility.

As regards the *emission of acoustic signals by the trains,* signposts have been erected before all level crossings without technical protection. On reaching this point, the driver of the train must ring his bell until the front of the train has cleared the crossing; in addition, at the point indicated by the signal he must blow his whistle or horn, and if necessary, do so again before reaching the level crossing. Acoustic signals are particularly important for giving warning of the approach of a train when it is dark or visibility is poor. The signposts are erected at a distance of 5 V (fig. 10) from the level crossing. In this way, the approaching train warns road users by an audible warning for as long a period as the distance of visibility for a slow vehicle according to the RÜW Clauses (audible distance = visibility distance).

Another protection is the *front lights* of the trains which give warning of their approach to road users when it is dark. These must be easy to recognise, without any confusion with the lights of road vehicles. As this condition was not automatically fulfilled with the old lights which consisted of two lights, especially when the road and railway ran side by side for some distance or when they crossed each other at a sharp angle, the Deutsche Bundesbahn at the beginning of 1955 introduced a new type of front light for trains on secondary lines consisting of three lights in the form of an A (fig. 11).

The following arrangements are used on Federal territory to give *warning and notice* of level crossings whether they are equipped or not with gates or with winking lights :

1. *Warning signals for automobiles* (fig. 12 and 13);

2. *St. Andrews Cross* (fig. 14);

3. *Warning boards* (fig. 13).

In addition, the following signals may also be erected :

4. *Signposts showing the speed restrictions* (fig. 15), and

5. *Signposts indicating that it is forbidden to outrun* (fig. 15),

in conjunction with the signals 1 and 3, or else lines are painted on the road to show that vehicles must halt.

On all roads open to general motor traffic, the level crossings are sign-posted with the *warning notice for automobiles;* in the case of level crossings equipped with gates, this shows a barrier (fig. 12) whereas in the case of crossings without gates, including those with winking lights, with or without automatic half-gates, the sign shows a locomotive (fig. 13). As a rule the warning notices are erected on the right hand side of the road, 120 to 250 m (131 to 273 yards) before the crossing. As they must be clearly visible to all drivers no matter how fast they are going, they must be very easy to recognise. On roads with heavy traffic, they are fitted with reflectors.

The *St. Andrews Cross* giving warning of a level crossing is usually sited 5 m (5.46 yards) in front of the nearest rail, on the right hand side of the road, or if special local conditions make this necessary, on the left hand side, or even on both sides of the road. The St. Andrews Cross marks the place at which motorists must halt when a train is approaching. The different forms of this notice show the road users how many lines there are and the type of protection at the level crossing. Fig. 14 shows two types, both used at level crossings without gates. One conforms to the requirements of the BO Regulations, but owing to its great height above the road, is difficult to see in poor light. The second was introduced three years ago by the DB to remedy this drawback. The new St. Andrews Cross starts 1 m above ground level and is turned at an angle of 90° so that the arm does not stick out into the road. In addition, the double cross formely used on crossings with more than one line has been replaced by a single cross with the red broken up. In the future only these new types will be used on the DB as they have given complete satisfaction.

Between the warning notices and the St. Andrews Cross beacons are erected every 80 m (87 yards) to remind the motorist repeatedly that he is approaching a dangerous place. At the same time they show how far away this point is and are in addition a supplement to the warning signal if this has not been noticed. The beacons are sited low down on the right and left hand sides of the road, with red globes or reflectors. The highway authorities are responsible for erecting them; unfortunately, they have not yet been used on all the roads with heavy motor traffic. But as they serve as a reminder that a level crossing is at hand and thereby greatly increase the safety, the DB is doing all in its power to see that the highway authorities erect such signals at all level crossings used by a considerable amount of motor traffic.

Responsibility for erecting and maintaining the protective installations :

The *Railway Administration* is responsible for erecting and maintaining the gates, the winking lights, the track marks and signals, and the St. Andrews Cross as well as the installation and maintenance of the visibility triangular boards for the roads which are not included in the legal regulations relative to crossings, and has to bear the whole cost of these protective devices. It is only at level crossings which so far have not been equipped with technical protection, where the increase in the road traffic makes it necessary to install gates or winking lights, that the highway authorities have to contribute half the cost of installation.

The *highway authorities* are responsible for erecting and maintaining the warning notices, beacons and other road signs, such as speed restriction notices, halt signs and lines on the road showing also that it is forbidden to outrun, and in addition are responsible for installing and maintaining the visibility triangular signs for the roads included in the law relative to crossings. The corresponding costs are however only partly met by the highway authorities, as the DB is

Fig. 16. — Road accidents and level crossing accidents.

N. B. — Bestand an Kraftfahrzeugen ohne Mopeds = number of motor vehicles, not included the motor cycles up to 50 cm³. Strassenverkehrsunfälle = road accidents. — Mittelinie = average. — Unfälle an Bahnübergängen (100 fach vergrössert dargestellt) = level crossing accidents (representation × 100). — Vierteljahr = 3 months.

TABLE 5. — **Road accidents and accidents at DB level crossings.**

Year	Road accidents			Accidents at level crossings on the DB					
	Number	Killed	Injured	Number	Killed	Injured	Number as % of road accidents	Killed as % of road accidents	Injured as % of road accidents
1949	161 800	5 000	90 000	(1)	(1)	(1)	—	—	—
1952	375 430	7 590	232 852	774	107	356	0.21	1.41	0.15
1953	445 538	10 954	297 916	760	139	441	0.17	1.28	0.15
1954	493 473	11 655	316 993	691	157	484	0.14	1.34	0.15
1955	567 228(2)	12 255(2)	350 408(2)	757	129	457	0.13	1.05	0.13

(1) Exact figures not available.
(2) Provisional figures.

obliged to pay half the cost of erecting the visibility triangular signs and half the cost price of the beacons.

V. Accidents at level crossings.

As we said in our introduction, the number of motor vehicles on German Federal territory since the currency reform in 1948 has increased to an extent that cannot be paralleled in any other country during the same period (see Table 1). As the roads open to traffic have not increased to any appreciable extent during the same period, it follows that the traffic on all the roads used by motorcars is much greater than ever before. This remark also applies to about 6 500 level crossings on public roads and highways suitable for general motor traffic. On the other hand, the number of trains on the DB has not increased to any extent during these last years. On the average the daily number of trains on Federal territory was :

29 520 trains in 1938,
28 544 trains in 1951,
32 560 trains in 1954, and
33 450 trains in 1955.

The terrible road accident statistics show the result of the rapid increase in motor traffic. Table 5 shows how the number of road accidents have increased from 1949 to 1955, and accidents at level crossings from 1952 to 1955; figure 16 shows the parallel between *the increasing number of motor vehicles* and *road accidents*, and below the *rather better evolution in accidents at level crossings*.

These provisional statistics show that on German Federal territory 12 255 people were killed on the roads in 1955 and about 970 persons injured every

day. Whereas more or less in parallel with the increase in the number of motor vehicles, the number of road accidents increased in the ratio of about 1 to 3.5 between 1949 and 1955, the proportion of accidents at level crossings on the DB has constantly diminished; in 1952, they were 0.21 % and in 1955 only 0.13 % of the total number of road accidents.

This satisfactory decline, obtained in spite of the constant increase in the amount of traffic, must be largely attributed to the special efforts made by the DB to avoid accidents at level crossings. Unfortunately public opinion has never fully appreciated this fact; on the contrary there have been constant attacks in the press for which there is no justification.

It is a striking fact that during recent years the accidents, which have occurred at level crossings, have become more and more serious. The ratio between serious and minor accidents has increased from 44 : 56 in 1951 to 60 : 40 in 1955. This is probably due amongst other things to the increased speed of motor traffic (in 1953, speed restrictions were removed in the German Federal Republic).

The Deutsche Bundesbahn is however doing all it can to assure and improve safety at level crossings. In order to be in a position to take effective steps in the future or to check the effectiveness of those already taken, it is necessary to study the accidents that have occurred as regards their number, their causes, the method of protection in force, etc. The German Railways for this purpose make use of special statistics relating to accidents and damage to gates at level crossings, based essentially upon the testimony given in court, which contain the characteristics that are of the greatest importance in the evolution of accidents, for example : place, kind, consequences, persons involved and type of protection in use. This special method was introduced in 1951. Fig. 17 shows some of the data for which figures are given in these statistics. It brings out the monthly fluctuations in the number of accidents and cases of damage to gates. The latter are of particular importance in view of their relatively high number. Damage to gates whilst they were being closed or were already closed amounted to 1 666 in 1955, or 4-5 per day; they were nearly all due to lack of attention on the part of the motorists.

As in the case of road accidents in general, accidents at level crossings are nearly always due above all to the behaviour of the individual. Thus during recent years about 50 % of the accidents at level crossings were the fault of road users (about 80 % being attributable to motorists), and only about 8-9 % were attributable to railway employees. Enquiries into accidents have established that only a very few accidents were due to mechanical defects in the motor vehicles, or to the steering or brakes going wrong. In the majority of cases, at level crossings with technical protection, the road users were at fault in not observing that the gates were being closed or were closed, or that the winking lights ordered them to stop when gates that should have been closed were open, and in the case of level crossings without technical protection,

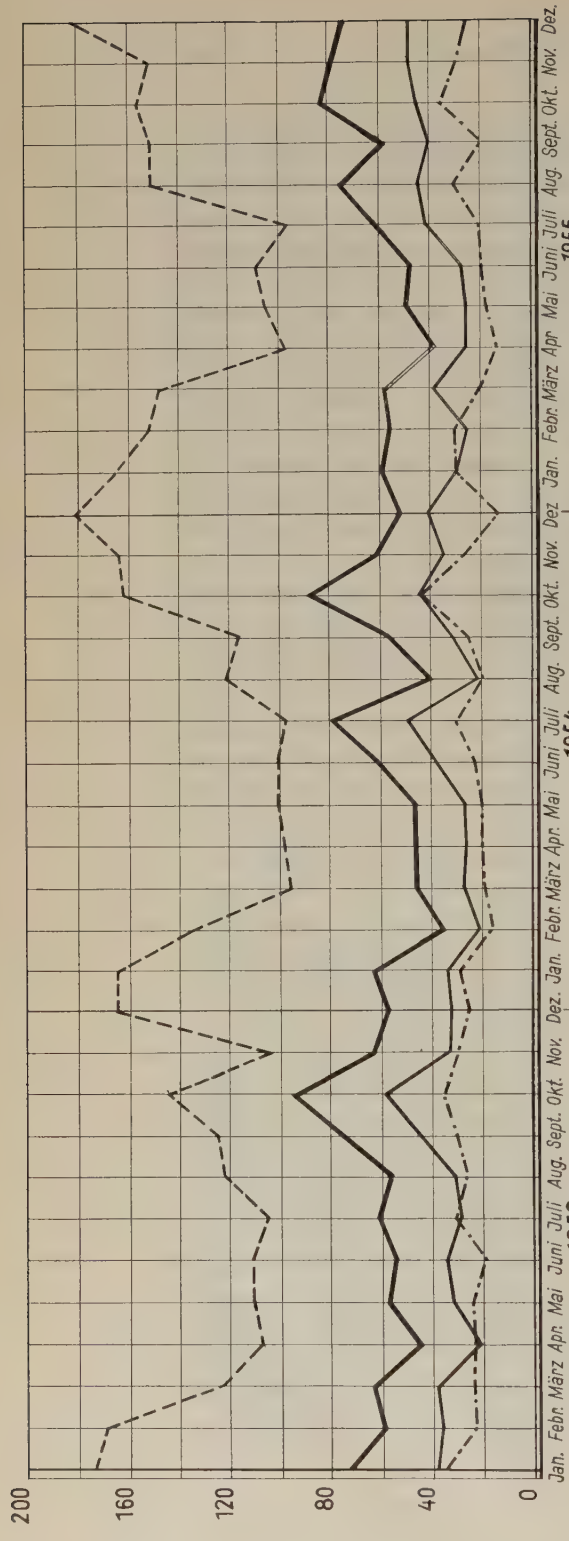


Fig. 17. — Monthly figures of accidents and damages to gates at level crossings since 1953.
——— serious and light accidents. —.—.—.— light accidents.
——— serious accidents. — — — — damages to gates.

did not notice the acoustic signals given by the trains; or again in failing to observe the line, or trying to get across in front of a train that had been seen, or to a lack of attention due to excessive fatigue, too much drink, or talking or listening to the radio. Mistakes made by railway employees have been chiefly keepers failing to close the gates in time or forgetting to close them altogether, or else opening them prematurely. Cases in which drivers have been at fault are extremely rare.

The general difficulties experienced on the road due to *the mixed nature* of the traffic which consists of motor vehicles, motor bicycles, bicycles, pedestrians, carts and push-carts, also have unfortunate repercussions at level crossings, especially those fitted with gates. It is often found that the keepers have the greatest difficulty in shutting the gates in the case of danger, due to the lack of discipline amongst certain road users who will not stop when they see the gates are closing, which makes it very hard for the keepers. At peak periods of road traffic, this has become so serious that at many level crossings where the traffic is heavy special lookouts have to be provided to stop the road traffic.

According to the above mentioned causes of accidents, the chief cause of accidents at level crossings is due to the human factor, to the failure to observe the most elementary traffic rules, and to insufficiently quick reactions. These causes of accidents that could have been avoided in most cases must therefore be met by adopting suitable measures, in the forefront of which must be the education of the individual in proper road manners.

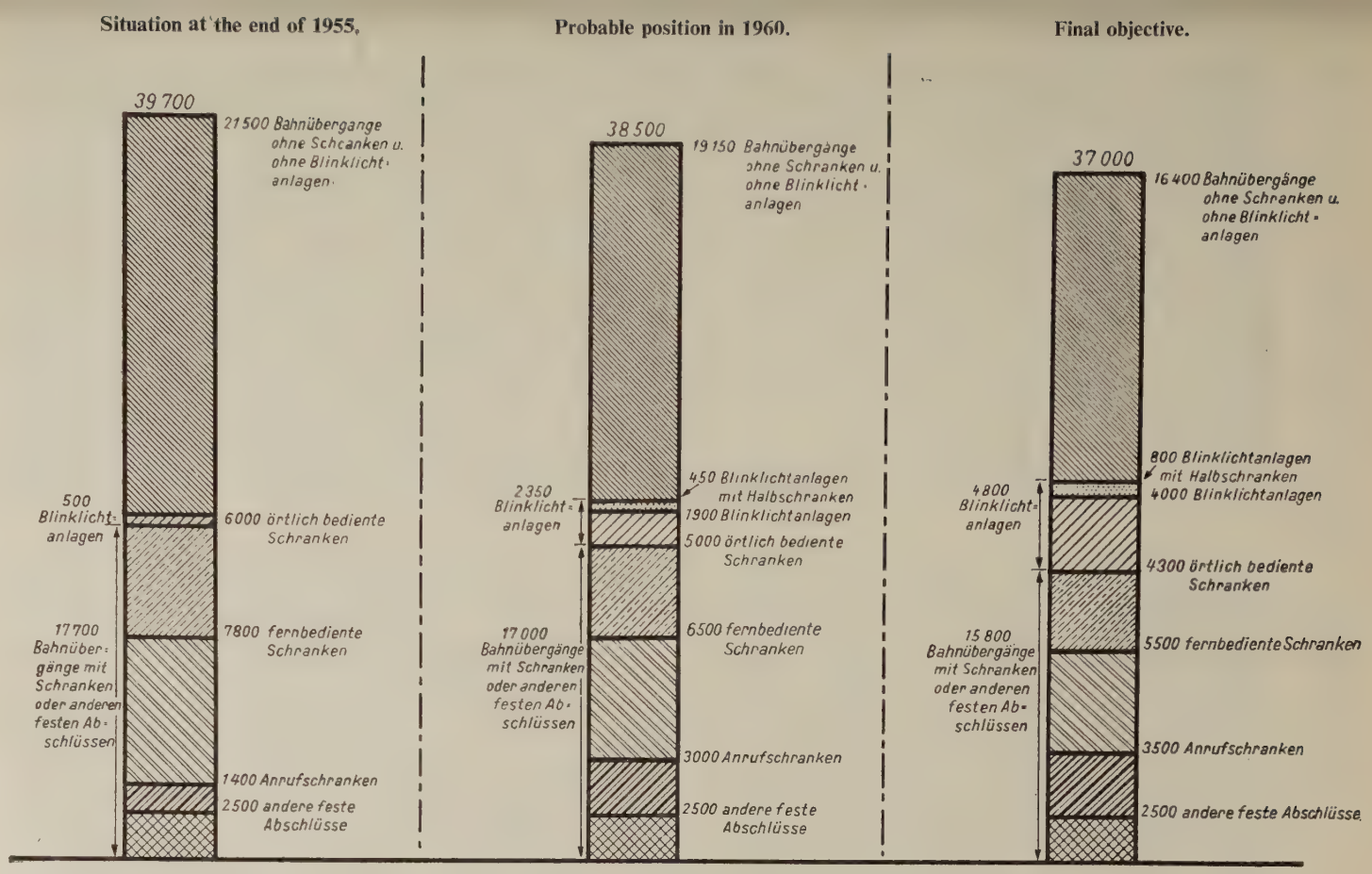

Situation at the end of 1955.
Probable position in 1960.
Final objective.
39 700
21 500 Bahnübergänge ohne Schranken u. ohne Blinklichtanlagen
500 Blinklichtanlagen
6 000 örtlich bediente Schranken
17 700 Bahnübergänge mit Schranken oder anderen festen Abschlüssen
7800 fernbediente Schranken
1400 Anrufschranken
2500 andere feste Abschlüsse
38 500
19 150 Bahnübergänge ohne Schranken u. ohne Blinklichtanlagen
2 350 Blinklichtanlagen
450 Blinklichtanlagen mit Halbschranken
1900 Blinklichtanlagen
5 000 örtlich bediente Schranken
17 000 Bahnübergänge mit Schranken oder anderen festen Abschlüssen
6500 fernbediente Schranken
3000 Anrufschranken
2500 andere feste Abschlüsse
37 000
16 400 Bahnübergänge ohne Schranken u. ohne Blinklichtanlagen
800 Blinklichtanlagen mit Halbschranken
4000 Blinklichtanlagen
4800 Blinklichtanlagen
4300 örtlich bediente Schranken
15 800 Bahnübergänge mit Schranken oder anderen festen Abschlüssen
5500 fernbediente Schranken
3500 Anrufschranken
2500 andere feste Abschlüsse

Fig. 18. — Protection of level crossings on the Deutsche Bundesbahn.

Explanation of German terms :

Bahnübergänge ohne Schranken u. ohne Blinklichtanlagen = level crossing without gates and without winking lights. — Blinklichtanlagen = winking lights installation. — Örtlich bediente Schranken = gates operated locally. — Fernbediente Schranken = gates operated from a distance. — Anrufschranken = gates normally closed (opened on request). — Andere feste Abschlüsse = other closing devices. — Bähnübergänge mit Schranken oder anderen festen Abschlüssen = level crossing with gates or other closing devices. — Blinklichtanlagen mit Halbschranken = winking lights with half gates.

VI. Steps to be taken in the future to increase safety at level crossings.

In years to come, the DB will continue to take those steps which experience and observation have shown to be the most useful in increasing safety at level crossings, with any other measures that may occur to them, provided they are financially supportable and economic. In this field, safety and rationalisation should go hand in hand.

Fig. 18 shows the present position as regards the protection of level crossings on the Deutsche Bundesbahn, as well as the improvements to be carried out towards 1960, and the long term objective aimed at, according to the present stage reached in the technique of protecting level crossings.

The steps to be taken in the future are :

1. *Doing away with level crossings :*

The most effective way of completely eliminating danger at level crossings is to construct bridges or subways. Doing away with all the level crossings, which immediately comes to mind, and which periodically is made an issue, comes up against the difficulty of the cost, which would amount to many thousand millions. It is impossible to expect the allocation of so much capital within the foreseeable future, or even any considerable proportion thereof. Such enormous expenditure would moreover only make it possible to avoid a small proportion of the level crossing accidents, which already only amount to a very small fraction (0.13 %) of the total road accidents.

The increasing burden of a great many level crossings, chiefly in the towns and in places with heavy mixed traffic, makes it imperative to replace them by bridges or subways. The limited financial resources of the Deutsche Bundesbahn, as well as the unfair division of the cost which we have already mentioned in Chapter III, only makes it possible to do away with level crossings, even in the most urgent cases, by degrees, and even then in not nearly sufficient cases. Even if only 1 000 level crossings were replaced by bridges or subways, it would cost about 1.0 thousand million DM.

In order to decide the urgency of replacing level crossing with heavy traffic on a standard basis, this year the DB had adopted a method of calculation based on traffic counts, which takes into account not only the amount of road traffic but also the number of trains, as well as local conditions (kind of road traffic, width, slope and angle of crossing) according to which the traffic figures are increased. From these calculations, it appeared that on the whole DB system there are 150 level crossings the replacement of which is a matter of the greatest urgency. According to 1955 prices, this would cost some 230 million DM; some of the bridges, especially those in the centre of large towns, would cost as much as 5 million DM The amount of time required to carry out these proposals is simply a matter of finance, so that it is not possible to make any statement at the present time.

Other ways of getting rid of level crossings are the *suppression of roads of secondary importance,* by diverting them

to neighbouring bridges or subways — which does away with all risks — or diverting them to neighbouring level crossings — which eleminates some of the risks.

The suppression or diversion of roads, as well as the construction of bridges or subways have made it possible to suppress a larger number of level crossings year by year : more than 230, for example, in 1954 alone. These efforts will continue.

2. *Development of winking light installations :*

Signals by means of winking lights, with or without automatic half gates, are to be installed in years to come at level crossings which to date have not been equipped with gates or winking lights, where there is a large amount of motor traffic, as well as at places where there is less traffic but where it would cost too much to comply with the visibility requirements of the RÜW, or again in those case where other special factors increase the risk of accidents. In addition, it is proposed to replace gates by winking lights in certain appropriate cases. This eliminates the human factor and saves the cost of keepers. By the end of 1955, about 500 such installations were in service; in the next 5 years, 2 350 are to be installed, and the final objective is some 4 800 (fig. 17).

3. *Improving the visibility :*

Most level crossings without gates or winking lights already comply with the visibility requirements of the RÜW. But the DB is doing its best, whenever possible, to improve the visibility at other level crossings, although the law only stipulates in the case of crossings with little traffic a visibility of 50 m (54 yards) over the line from the St. Andrews Cross, the train to give audible signals (bell and whistle).

4. *Increased number of gates that are opened on request (Anrufschranken) :*

The DB is attaching more and more importance to gates opened on request — i.e. normally closed — owing to the increased safety they give road users. Their advantages, especially when combined with loudspeaker installations with two way reception have already been described. But their installation is constantly coming up against difficulties because the road users do not recognise that this increases their safety and feel that their freedom is impeded. As the loudspeakers make it possible for information to be given to the road users, as well as quicker operation of the gates, it is likely that in the future this method of working the gates will be extended.

5. *Installation of remote operating devices for gate keepers :*

To keep the keepers fully informed about the running of the trains, for some years trials have been carried out of improved methods, for example *hearing the announcement of the departure of the trains by telephone or loudspeaker.* The announcements of the departure of trains, sent by telephone from station to station, are received by the gate keeper by telephone or by means of a loudspeaker erected on the line. He is thus advised of the category (fast or slow train) and time of departure of the train

and can therefore deduce its probable time of arrival fairly accurately.

At crossings where the visibility is poor, it has been the practice for some to install *automatic devices announcing the arrival of trains* (zugbediente Zugvormelder).

This device warns the keeper of the approach of a train by means of an optical and acoustic signal worked by the train itself when it runs over a switch. The distance of these switches from the actual crossing (warning sections) is a function of the maximum speed of the trains and the time required to close the gates. The warning is given by the lighting up of a lamp and by a horn which sounds until the keeper turns it off. A loudspeaker can be added to these installations to advise the keeper of the class of the train.

On lines equipped with the automatic block, the keeper has an illuminated track diagram extending over two or three block sections on either side of the level crossing. When the approach sections are occupied, the light on the corresponding sections of the diagram change from yellow to red and an electric bell rings. Here again the installation can be completed by a loudspeaker.

On lines equipped with the automatic block, with announcement of the train numbers, for example the Nuremberg-Ratisbonne line, as a trial, *devices announcing the class of the train* have been installed in the level crossing keepers' boxes. In addition to the lighting up of the sections of the track diagram and the bell, the keeper is given an optical indication of the category of the train by means of the letters L = slow, M = average speed and S = express.

It is proposed to extend the telecommunication devices described above.

6. *Servicing level crossings according to requirements :*

There is a whole series of level crossings where there is a great fluctuation in the amount of traffic according to the time of day or the season of the year. For example this is the case with level crossings equipped with gates in agricultural regions, which are used a great deal during the ploughing or harvesting seasons, but hardly at all at other periods of the year, or those leading to factories which are used almost exclusively only at the times the shift is changed or at the beginning and end of the day's work. In future the gates at such level crossings will be so designed that according to the amount of traffic, for example, gates normally operated at site can be temporarily operated from a distance or temporarily operated on demand, and gates operated normally at a distance can temporarily be only operated on demand.

7. *Guiding public opinion and educating the public as regards traffic sense :*

As about 90 % of all the accidents at level crossings are the fault of the road users, the DB is doing all it can at the present time, by means of articles in the press, advertisements, radio programmes, films and organised visits to call attention to the special dangers of level crossings and educate all road users in the safety installations. The correct behaviour at level crossings and the traffic regulations to be observed have been collected together in an illustrated

pamphlet many copies of which have been distributed to the public. A very striking film : « Attention, Level Crossing » has been made which is shown at the beginning of cinema programmes.

But as experience has proved that these attempts to educate the public by the railway are not sufficient to lead to any lasting improvements in the unsatisfactory behaviour of road users at level crossings, attempts should be made to get the police to carry out traffic checks much more frequently than at present. The railway police also can help by keeping a check on the discipline of the road traffic.

8. *Organisation measures :*

The work of carrying out the measures intended to improve safety at level crossings has become increasingly important in the last few years and perfect mastery of this subject means acquiring an ever increasing amount of special knowledge. The Deutsche Bundesbahn has therefore been obliged to take certain organisation measures in order to assure that all the duties involved are fully carried out.

For some years there has been a special working group on the German Federal Railways responsible for studying the protection of level crossings. During its regular meetings this organisation has prepared a memorandum which contains all the proposals regarding the adaptation of the protection of level crossings to modified traffic conditions, and the safety measures to be taken to obtain the maximum security. These proposals have already been partly applied in the form of immediate measures. The working group is still continuing its investigations in order to be able to express an opinion on special improvements and to advise on the elaboration of new regulations or the revision of the present railway regulations.

For instituting and carrying out part of the proposals contained in this memorandum, in 1952 a special department was set up attached to the Munich Bundesbahn-Zentralamt to deal with level crossings, responsible in particular for the following duties over the whole of the Federal territory :

a) Elaboration of directives for the protection of level crossings. Drafting regulations covering the question of the protection of level crossings;

b) Verification and estimation of new proposals in the field of the protection of level crossings;

c) Preparation of documents intended to educate public opinion about the proper behaviour to be shown at level crossings;

d) Making use of level crossing accident statistics;

e) Investigation of the documentation on the protection of level crossings.

For each of the Managements of the Bundesbahn, one of the technical permanent way department heads has been made responsible for dealing with all the level crossings in the whole of the territory concerned. These officials deal essentially with the question of the protection of level crossings, so that they are specialists to some extent, as this has been found necessary and advisable in order to enable them to master completely the whole of the numerous technical,

legal and organising problems involved in the protection of level crossings.

Inspection and current local control of the protective measures at level crossings, to which great importance has been attached in recent years, are the responsibility of the Bundesbahn inspectorates and workshops.

VII. **Conclusion.**

The foregoing report shows that the DB, at the cost of considerable expense to itself, has made every effort to increase safety at level crossings. Here it is not a question of catching up with the delays due to negligence, but rather the constant adaptation of the protection of level crossings to the rapid increase in road traffic by making use of the most up-to-date technique and adopting approved methods of organisation and education. It cannot be denied that the efforts expended to date have met with some degree of success. However, in order to make a lasting reduction in the number of accidents at level crossings, a great combined effort on the part of all those concerned with the traffic over these crossings is essential.

Statistics as well as daily experience show that the overwhelming majority of accidents are due to a mistake on the part of the road users, and also to some extent it is true, though to a much less extent, to mistakes on the part of railway employees. Maximum security is therefore only possible if human error can be completely eliminated (replacing all level crossings by subways or bridges). This solution however is only possible at a cost that would be beyond the national economy. Educational measures must therefore be strengthened in order to reduce to the minimum the carelessness of behaviour so often noted, as well as the failure to observe the most elementary traffic rules. If this could only be achieved, the number of accidents at level crossings would be considerably reduced, and they could be maintained within a supportable limit.

[625 .215 (43)]

The evolution of the carriage bogie in Germany.

From the pivoting truck to the Minden-Deutz 50,

by Julius Paul (Minden.)

(*Eisenbahn Technische Rundschau*, March, 1955.)

The problems of running gear have always been of great importance in the design of railway vehicles and same is today greater than ever because of the speeds of operation. We therefore regard as very important and very instructive the following survey in which the author gives a very complete review of the development of carriage running gear for express vehicles in Germany during a period of nearly 120 years. It is all the more valuable since many of the documents which the author — who has been professionally engaged in bogie construction for more than 20 years — used to trace and describe the early development, are today lost owing to the events of the war. This article therefore appears to be extremely valuable as a survey of development and a historical record as well as a guide to possible future development.

The Editor of « E. T. R. ».

1835 :

Operation of the first steam train from Nuremburg to Furth; its two-axled coaches were designed on the lines of the existing road vehicles. However, in

1839 :

the first four-axled coach with pivoting trucks was delivered by a Belgian firm to the Rheinische Eisenbahn (REG) (1). Subsequently, several German Railways put into service identical vehicles which were constructed on the lines of the American coaches (2); these were known as intercommunicating coaches; that is, with end platforms, central corridor and seats which could be reversed to suit the direction of travel.

The running gear of these four-axled coaches, some specimens of which still exist under certain service wagons, comprised simple pivoting trucks, of about 1 270, 1 450 or 1 600 mm (50″, 57″ or 63″) wheelbase. The two axles were mounted in one frame which at first consisted simply of two wooden solebars strengthened by two plates. These solebars were connected at the centres by a cross-bearer and at the ends by wooden headstocks or by iron spacing bars. The cross-bearers were fitted with a socket in the centre.

The frames, which at first rested on the axles without springs, were later fitted with laminated springs bearing on the axleboxes.

The laminated springs were set in line with and underneath the solebars; the springing of the solebars under vertical load was therefore good.

The four-axled coach of the REG delivered in 1839 had a brake with eight brakes shoes which acted on the extreme axles only. The bogies had wooden headstocks designed to take braking stres-

(1) Edmund Heusinger von Waldegg : « Atlas zum Handbuch für speziale Eisenbahntechnik » (Railway Technical Manual), t. II, 1870.

(2) « 100 Jahre Deutsche Eisenbahnen » (100 years of German Railways), pp. 168 and 177.

ses. Later, coaches of the Wurtemberger Railways had, on the contrary, brakes with four inside shoes acting on the extreme axles. With this arrangement the wooden headstocks could be replaced by the simple spacing bars mentioned above.

1861 :

Chains to restrict the pivoting of the bogie were prescribed ([3]).

A new step forward was made in the evolution by the special vertical suspension of the cross-bearers on the bogie frame.

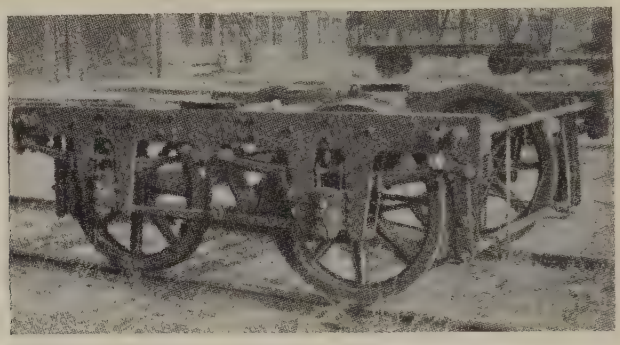


Fig. 1. — Pivoting truck of the earliest type for passenger carriages.

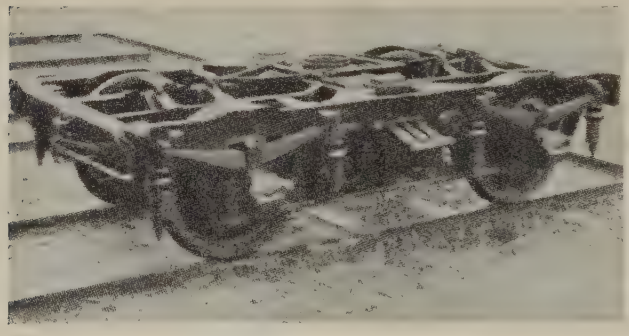


Fig. 2. — Prussian standard type bogie.

In other coaches, the brake shafts were located in the axle centre line, so that even if the shoes were set outside, the simple spacing bars were sufficient for end stays. Circular segments arranged laterally on the cross-bearer, the present side-rubbing blocks, were fitted from the beginning to prevent excessive inclination of the body, which rested only on the two centre sockets.

With the growth of traffic, bogie vehicles became more and more important.

([3]) « Entstehung und Entwicklung der Bestimmungen der TV über Drehgestelle » (Origin and development of technical regulations for bogies), published by « Verband Mitteleuropäischer Eisenbahnverwaltungen », compiled by « Oberreichsbahnrat Mertz », § 190, p. 6, 8-wheeled carriages.

1890 :

Construction of the first German bogie following the present basic design, that is with swing bolsters guided longitudinally and free to move transversely, designed for express vehicles which until then had had three axles.

Following joint consideration by the Royal Magdebourg Railway Administration, then the controlling body for carriage design, and the « Breslauer AG. für Eisenbahnwagenbau » (later « Linke-Hoffmann Werke »), the standard Prussian bogie was designed in pressed plate with double suspension, swing bolsters with pendulum suspension in the frame and four inside brake shoes.

1891 :

Breslau were already building a modified bogie for express coaches of the Erfurt Railway; same frame, but in plate iron, with 8 brake shoes (4) and counterweight for hand brake.

(4) Contrary to the figure of brake blocks mentioned at the beginning which referred to the whole vehicle, these and the following figures will refer to one bogie.

1893 :

Breslau constructed the pressed steel frame with eight brake shoes, which was followed by other types, varying only slightly.

1895 :

Construction of the first normal Prussian type bogie for compartment coaches.

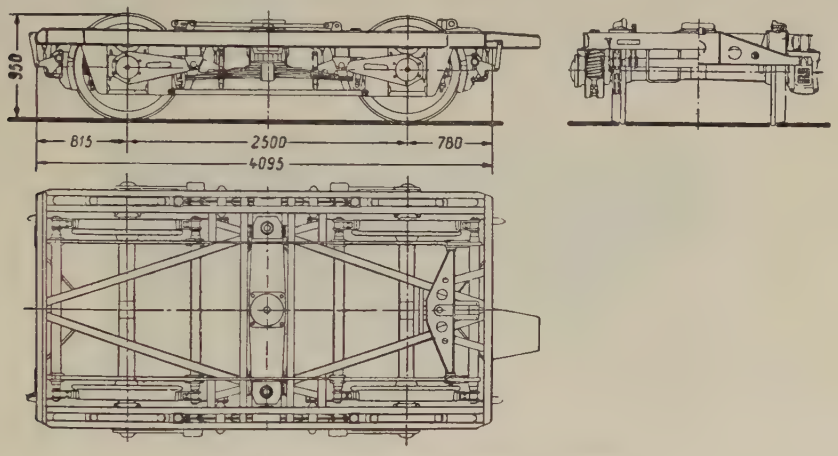


Fig. 3. — Langenschwalbach type bogie.

1898 :

Mention was made in the « Eisenbahntechnik der Gegenwart » (Present Railway Technique) in a chapter on Coaches and Brakes, of the two-axled bogie for secondary lines, « Langenschwalbach » type. Constructed for the Wiesbaden - Bad Schwalbach line, with simple longitudinal laminated spring suspension and no swing bolster. The springs rested directly on the axleboxes. The frame guided the axles, which were maintained parallel by means of special longitudinals located on the axleboxes. The body was carried on lenticular sockets and by spring rollers directly on the frame which in turn rested by its moveable middle-bearer on the suspension spring links. Bogies of the Langenschwalbach type are running

at the present time on main lines, although with a restriction as to speed.

As passengers became accustomed to bogie vehicles their demands became greater. Increasing numbers of complaints were heard, particularly as regards rough riding and violent lateral shocks (from the swing bolster). First attempts to relieve this were by inserting supplementary helical springs in the axle suspension and then by building three-axled bogies, especially for the luxury sleeping cars and special vehicles of the Royal train, etc.

the so-called « Jakobs » bogie supporting the adjacent ends of two successive vehicles. The coupling of the coaches above the « Jakobs » bogie consisted of a pivot and bearing ([5]).

At this time, Government Counsellor Glasenapp, attached to the Imperial Embassy in Washington, drew up a report « On the running of bogie coaches »; this report was sent by the Prussian Minister of Public Works to the Royal Railway Management who were invited to proceed with an investigation into

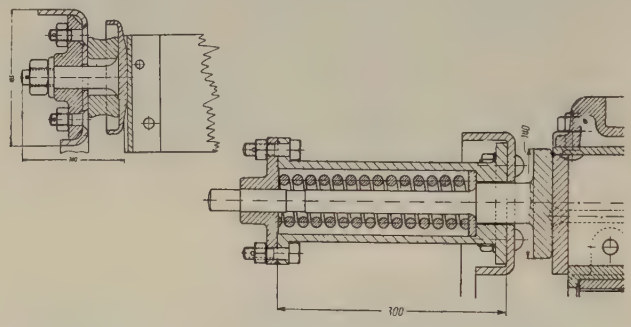


Fig. 4 and 5. — Transverse shock absorbers for swing bolster.

The helical spring axle suspension, called the third spring, was adopted partly to control the height of the frame by suitable tension but also, and mainly, to destroy oscillation transmitted to the frame by the laminated springs which were directly connected to it. This is explained by the fact that laminated springs made up of several layers do not respond to small forces because the friction between the laminations is greater than the forces acting outside the springs. In this event the spring acts as a rigid beam and the forces acting on it are transmitted as vibration to the bogie frame.

1901 :

The « Waggonfabrik Rastadt » designed a three-coach unit with single end axles and a common bogie of a special type,

ways of improving bogies and to submit proposals for the construction of a more suitable design.

1904 :

Following this investigation, a batch of two-axled American Pennsylvania bogies as described in the Glasenapp report, with soft double suspension and wooden frame, as well as spherical sockets and non-adjustable spring links, was built by the « Breslauer A. G. für Eisenbahnwagenbau ». They were known as American wooden bogies. In addition, an order was placed with the same company for an English bogie, very similar in design,

([5]) Wilhelm JAKOBS : « Entwurf zu einem Gelenkwagen für Eisenbahnzüge, Bauart Jakobs » (Proposal for an articulated coach for railway trains, Jakobs type), 1901.

of « standard type » in which the coach body was entirely supported by the side rubbing blocks. The centre pins were used solely for guiding.

In 1904, the Breslau Works also built the first bogie for the ferry-boat service with Denmark.

To overcome the much-criticised lateral shocks, trials were carried out with transverse suspension of the swing bolster by means of helical springs, rubber pads, etc. In 1904, the Berlin Railways Management undertook comparative trials with

By the use of swing bolster dampers it was thought possible to stabilise the running of the coach, provided that the spring tension was correctly calculated.

In 1904, the firm of van der Zypen, Cologne-Deutz, constructed a special type of bogie with guides for the axles and bolster, which was later put on test.

In the same year, the « Regierungsbaumeister » published in Berlin a collection of drawings of bogies for express carriages and this appeared in a special number of *Glasers Annalen*.

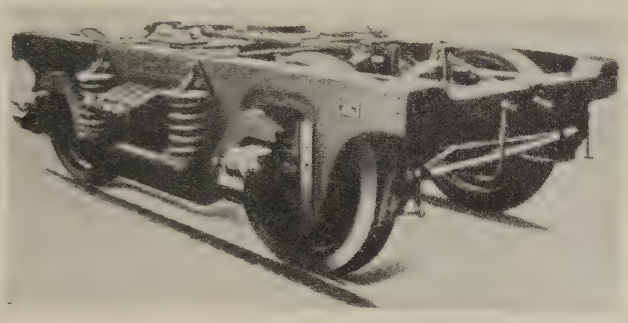


Fig. 6. — American type bogie.

these « swing bolster dampers » on American, English and Prussian standard bogies. The American bogies were more resilient vertically than the Prussian standard type because of the greater effect of the helical springs in the whole suspension. They had, however, one drawback, which was the undesirable transmission to the frame during a brake application, of the load on the axleboxes. The considerable weight of the swan-neck equalisers made it necessary to restrict the wheelbase to 2 150 mm (84.64″). The English bogies had longer bolster suspension links and consequently offered a reduced amount of transverse oscillation. However, they caused vertical vibrations in the body so that on the whole this type too did not show any appreciable advantage.

1906 :

The general adoption of swing bolster dampers was prescribed. The « Breslauer A. G. », already mentioned, built the first bogie, which was of the three-axled standard type.

1907 :

Following trials undertaken by the Bromberg, Berlin and Essen Railways, it was established that the best running qualities were obtained with bolster and suspension links 175 mm (6.88″) long, arranged *vertically*.

In the same year, the Dortmund Works Inspectorate designed a recorder for measuring vibration. This equipment recorded on a continuous band the accelerations caused by the different movements,

by means of a determined mass suspended in the device and free to oscillate. This made it possible to obtain objective comparisons. Until then, proposals for improvement had been based on the impressions received by passengers during trial runs. The new device, at first constructed in separate parts for recording vertical and horizontal oscillations, was later designed to record both directions, the two curves being recorded side by side on a single band.

Comparative trials undertaken with this device on the Potsdam-Magdebourg and Dortmund-Herne lines with different types of swing bolster dampers, including hydraulic types, showed that, contrary to opinions previously expressed, steadier running was obtained without dampers. The dismantling of the dampers was therefore prescribed in 1909.

1908 :

The Essen Railways undertook a series of line tests between Dortmund and Hamm which confirmed the decision of the Passenger Carriage Commission following trials on the Postdam-Thale line with the types of bogies specified at their 42nd session, according to which the American bogie was superior to all the others. The Ministry therefore authorised in the same year the fitting of 25 express carriages with two-axled American bogies.

1909 :

The use of this bogie only for new construction was then specified.

In the same year the Essen Railways attempted, on the Dortmund-Wanne line, to improve the axle suspension by means of an equaliser. The results were negative. The bogie showed so much tendency to pitching during running that it was declared unsafe for operation. The same tests were made again in 1942 in Belgium by M. Montrose Ostére, of Brusels, and these seem to have been successful.

1910 :

The exclusive use of stepped centre sockets in place of spherical sockets was ordered for the American bogies.

1912 :

The Altona Railway suggested the adoption of trunnion mounting for swing bolster suspension links, « Othegraven » type. Trials subsequently carried out by the Dortmund Works Inspectorate gave favourable results. The same experience was obtained with comparative trials on the Postdam-Goslar line in 1913, between standard bogies with and without Othegraven suspension. With this suspension, the rotation effect ensures a more uniform recoil effort and in addition the rocking arrangement allows displacement of the bogie bolster in a longitudinal direction, in other words perpendicular to the true plane of oscillation, which gives improved running.

Apart from these American and English trial bogies, comparative tests were also made with the special type with guided axles and swing bolster built by the van der Zypen Company of Cologne in 1904.

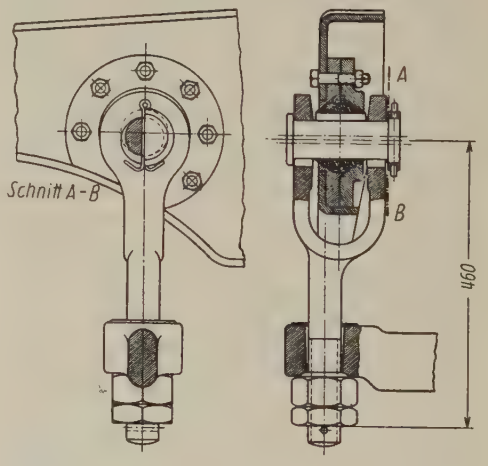


Fig. 7. — Othegraven ball type suspension.

N. B. — Schnitt A-B = section A-B.

1913 :

Adjustable swing bolster suspension links, similar to those on standard bogies, were specified for the American bogies.

1915 :

Construction of a three-axled American type bogie.

1923 :

The general use of « Othegraven » type bolster suspension including use on American type bogies was specified.

type bolster suspension was retained on the Görlitz type, although modified as a result of the design. It was greatly simplified. Whilst in the older types of bogie, the links were each articulated on one centre and fixed independently by transverse links, in the Görlitz bogie longitudinal movement of the bolster was on the contrary assured by suspension links mounted on one centre fixed to the solebar. Transverse movement of the bolster was allowed by short hanger bolts of fixed length, acting on the bolster spring straps. This gave a better action to the suspen-

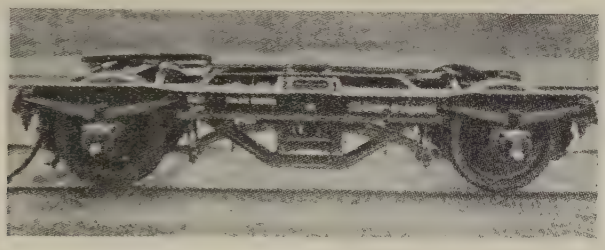


Fig. 8. — First Görlitz type bogie.

1924 :

Four AB4ü coaches and one sleeping car were for the first time fitted with a pressed plate type of bogie proposed by Reichsbahnrat Speer and built by Wumag of Görlitz — the Görlitz bogie, type I. The special feature of this bogie was that in place of the former transverse eliptical springs for bolster suspension, it had two long laminated springs arranged parallel outside the frame (so-called Görlitz springs), a long wheelbase of 3 600 mm (141″) and stay re-inforcement of the solebars.

Because of the reduced height of the solebars, the Görlitz bogie had over the American type bogie the advantage of improved accessibility. The brake shoes in particular were much more accessible and their replacement much easier than on the American bogie, where they were masked by the swan-neck equaliser and the helical springs. The « Othegraven »

sion links without the need for special arrangements. To arrive at the same results Othegraven would have had to arrange the rotary movement from the trunnion centre.

1926 :

The newly-established Carriage Testing Section undertook, at the Reichsbahn's Grunewald Repair Works, trials with various types of suspension ([6]). Görlitz type II was obtained following improvements to the frame. Additional suspension was provided between the frame and the axle laminated springs by volute springs and later by square section helical springs. The new bogie was adapted for sleeping cars, whose running qualities with American bogies had not

([6]) Speer : « Die Federn der Personenwagen » (Springs for passenger carriages), *Organ*, 1933, No. 7/8.

been satisfactory. Once again, however, heavy shocks from the swing bolster were experienced, which led to a series of line trials between Stuttgart and Bingen.

1927 :

Following these trials, a length of 200 mm (7.87″) was prescribed for bolster swing links of the Görlitz type III bogie. The same length was subsequently prescribed for the American bogie also.

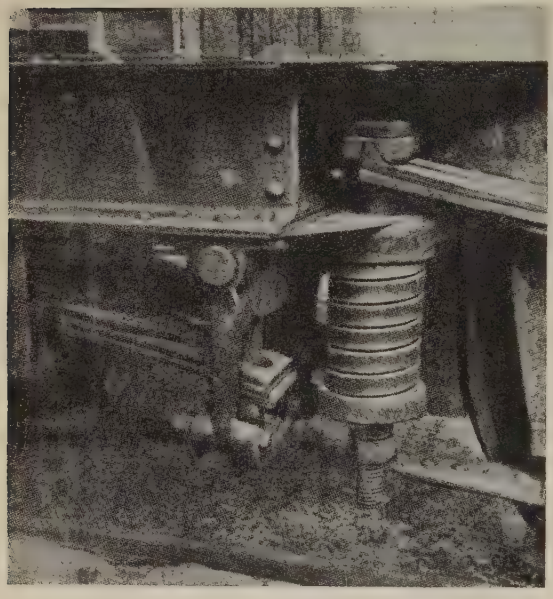


Fig. 9. — Bolster suspension of heavy Görlitz II bogie.

As it had been noticed during the latest tests that the Görlitz bogie was capable of further improvement, the Carriage Testing Section was instructed to undertake further trials to improve the running qualities of bogie vehicles. The line chosen for this purpose was the Postdam-Magdeburg-Nordhausen line; it had long sections without appreciable curves, most suitable for high-speed trials, as well as sections of irregular lay-out. This was the line on which the first Görlitz III bogie was tested.

The Görlitz III bogie differed from types I and II, as well as from the standard and American types, in the fact that it had a single-piece bolster which rested directly on straps of the Görlitz type longitudinal springs. The earlier bolster spring links were replaced by ring links which supported the ends of the laminated springs in a similar manner to those used on the two- and three-axled carriages (7).

1927 :

Construction for the Blankenese-Poppenbuttel line (Hamburg suburban area) of compartment vehicles as twin units of six axles. The outer bogies of these coaches were of the normal Prussian type, 2 600 mm (102.36″) wheelbase, and the central bogie was a Jakobs bogie of Görlitz pattern 3 500 mm (137.79″) wheelbase, with end couplings carried in common centre pin sockets.

As, in the meantime, the Reichsbahn Carriage Construction Works had offered for trial various designs of bogie and moreover was to construct the « Rheingold » long-distance express and the first corridor coaches for local trains (4 i), the Berlin General Management instructed the Carriage Testing Section to proceed with a new series of tests with the existing bogies of normal Prussian, American, van der Zypen 1904 and 1927, Fuchs 1927, Wegmann 1927, two Linke-Hoffmann 1927, MAN-Nürnberg 1927, Credé 1927, Uerdingen 1927, Uerdingen-Sheffield 1927 and the light and heavy English Leeds types. There was still a number of details to clarify; expert opinion was still not agreed on the most suitable type of bolster suspension, length of links, oblique or vertical setting, most suitable amount of play for the bolster, etc. The Grunewald

(7) « Das Görlitzer Drehgestell » (The Görlitz bogie), *Glasers Annalen*, 1904, No. 1133.

Testing Department selected the Oberndorf-Horb line, near Stuttgart, for the tests — this included numerous successive curves, for speeds of about 80 km/h (50 m.p.h.) — and the Burg-Brandenburg line for moderate speeds of 120-130 km/h (74-80 m.p.h.) and high maximum speeds of more than 140 km/h (87 m.p.h.).

For details of the Horb trials reference may be made to « Memorandum on the running of passenger vehicles » (Teilentwurf zur Denkschrift über den Lauf der Personenwagen), published in December, 1928.

Because of their long 3 600 mm (141.73") wheelbase, the heavy Görlitz types were

Fig. 10. — Görlitz bogie, type II.

Fig. 11. — Görlitz bogie, type III, heavy.

1928 :

The specified tests were carried out using a Dortmund oscillometer, improved in some technical respects by the Carriage Testing Section.

Following these trials, the heavy Görlitz type II bogie was adopted for the Rheingold train and the light Görlitz type III for the 4 i carriages. There was in fact also a light type of the Görlitz II bogie, but the type III was preferred because of the simpler bolster with suspension by ring link and torsion bar.

not usable for ferry-boat services. For this purpose, American type bogies with spherical sockets continued to be built until 1932.

1929 :

Experimental construction of the first welded Görlitz type III heavy bogie.

1931 :

Other bogies of this type followed. These were more rigid than rivetted bo-

gies. Thermal stresses due to welding at first caused frequent defects.

In the same year, Wumag developed and built the Görlitz type IV light bogie. This bogie was similar to the light type III; all components were greatly reduced in weight because of its exclusive use for coaches working on secondary lines and for light railcar trailers. Its dimensions were based on wheels having a diameter of 900 mm (35.43″) tread diameter. It was later built in large numbers for the Heidenau-Altenberg (Erzgebirge) line, converted to normal gauge.

1932 :

The coaches of the Rheingold train were fitted with new bogies of the Görlitz heavy type III, but still of rivetted construction, with slipper blocks. The heavy Görlitz II bogies with roller bearings which were thus freed, were fitted to the Munich-built express coaches delivered in 1927, in place of the American bogies which had not been satisfactory. At the same time, the Carriage Testing Division was making trials on the Magdeburg-Nordhausen line in an attempt to improve the suspension.

1933 :

Following the work of the Commission on Bogies (Agm), standards were specified for limits and tolerances in bogie construction ([8]).

To prevent impact noises from penetrating into the coaches when running, bogie centres and rubbing blocks were mounted on rubber. This, however, did not appreciably reduce the noise; on the contrary, because of the disintegration of the rubber under load, it was impossible to tighten up the centre socket and side block bolts sufficiently to take up all the play. This resulted in unstable running, damaged centre sockets or sheared bolts. Removal of the rubber pads was ordered in 1934.

Fig. 12. — Bolster suspension of heavy Görlitz III bogie.

1934 :

To determine the influence of rail head width on tyre wear and carriage running, use was made over a fairly long period of the tyres of three express coaches (AB 4ü) delivered in 1930 and fitted with heavy Görlitz II bogies on the Berlin-Magdeburg; Berlin-Hannover; and Berlin-Altona lines and after exact measurement

([8]) Dr.-Ing. Karl RAAB : « Versuche über den Lauf von Drehgestell-Personenwagen, insbesondere zur Erforschung der Abhängigkeit des Laufs von der Grösse des Spiels im Laufwerk » (Tests on running of bogie carriages, with particular reference to the relationship between running and play in motion parts, Thèse, 1931.)

of the components of the running gear the coaches were periodically subjected after reaching a predetermined mileage, to running stability tests on the Postdam-Rothensee-Stendal-Lehrte line, recently selected for this purpose.

The same year, several express and semi-express coaches were put into service on the Hannover - Cologne and Berlin-Cologne lines to provide information on the effect of tyre profiles, angle of slope, cant and gauge-tightening.

1935 :

To obtain smoother running, the interchangeability of axle and bolster guide plate liners was prescribed, as the Görlitz bogie had always been subject to the disadvantage of too much weakness. Because of the great length of the solebars, unstrentgthened axleguards and vertical forces acting laterally beside them, the axleguards spread both longitudinally and transversely. Because of the longitudinal spread it was thought that the slides and

Fig. 13. — Light Görlitz III bogie with quadruple suspension.

In 1934 also, a large scale trial was started on 100 express coaches, fitted with high-tensile steel tyres by the Postdam Repair Shops. These tests were followed by another series on four express coaches from the Opladen Works and four from the Neumunster Works, the tyres of which had been trued by the « Hanus » process on a milling machine designed by the Hegenscheidt Company of Ratibor, or by a simpler method evolved by the Neumunster Works. They were given a D.15 flat profile (R = 5 000 mm and r = 40 mm) or a D.13 profile with 1 : 40/1 : 20 coning.

All these tests, however, became purposeless because of the introduction of carbide turning of wheels in accordance with the method used by the Rotsdam Works [9].

axleboxes were becoming excessively worn. Transverse spreading caused hard and rough riding.

To reduce the wear, the heavy Görlitz II bogie had already had the inner horns of the axleguards braced by a flat iron bar — an axleguard tie bar. The heavy and light types III were also fitted.

Attempts were made further to reduce the wear by the use of wear-resistant material, for example « Rg. 5 », and after the banning of this, by the introduction of « GE. 14.91 » cast steel axleboxes. In addition, trials were made with slides having lubricants pressed in, in place of the automatic pad lubrication, which did not appear suitable in view of the common user of coaches because it required some maintenance. Later, tests were made with forced grease lubrication, proposed by the Opladen Works, which was at first used

[9] Schmidt-Bernsdorff : « Erfolge in der Radsatzbearbeitung durch Hartmetall » (Successful machining of axles with carbide tools), *Reichsbahn*, 1941, No. 4-5.

[10] Senior Technical Inspector Rellensmann.

manually and then made fully automatic, but it did not give the results hoped for because of the maintenance required in service, which — even though it was insignificant — was not done.

To overcome the transverse spread, the Görlitz bogie frame was re-inforced by welding an internal cover plate to the solebars (channels). The stays were connected to a considerable length of the solebar by specially-designed straps. In addition, the angle joints were systematically re-inforced and to eliminate bending of the axleguards special stays were welded on.

In the same year the strenthening of all Görlitz bogies was prescribed.

As tests showed that it was incorrect to assume that smoothness of running was dependent on reduced transverse play, the transverse dimensions of the axlebox guides were reduced to annul the effects of transverse spreading of the guards and it was specified that all vehicles in running order, but empty, should have a minimum play of 0.5 mm (0.0198″) from top to bottom. Attempts had been made to obtain the same result by bevelling the outer guide surfaces of the axleguards, but without the desired result.

In 1935, there also took place endurance tests on welded bogie frames with lap and butt welding but it was not possible to find the exact cause of failures of welded assemblies. It was definitely noticed that the angle joint then used, comprising flat steel stays welded to the main members by simple concave welding, the top of which coincided with the neutral zones of the pieces to be joined, could be considered as the best from the economic and welding points of view but for endurance under alternating loads, taking into account corrosion, it was not

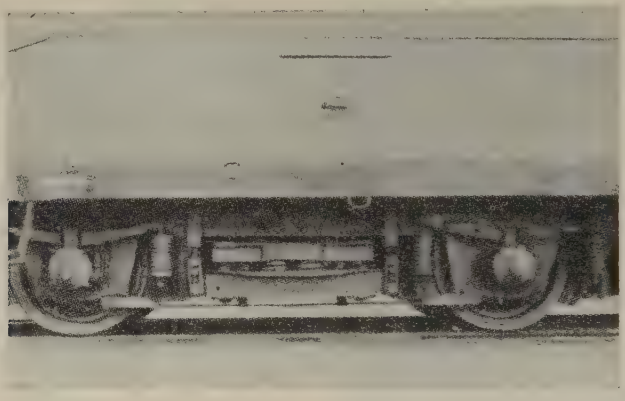


Fig. 14. — Bolster suspension with helical springs and oil-filled shock absorbers.

Fig. 15. — Teleskop oil shock absorber.

acceptable ([11]). Nowadays, this arrangement has been abandoned.

As vibration and shudder had not been eliminated, despite the reinforcement of the Görlitz bogie, trials with rubber springing of axles, insertion or application of plastic materials to wheel centres, rubber rollers of Krukenberg design under the bolster, and other similar measures, none of which had been successful, attempts were made to eliminate them by new helical springs. By this means appreciably improved running qualities were obtained. This so-called quadruple suspension was, after various tests, arranged between the bogie frame and the bolster laminated springs.

The year 1935 also brought the first newly-designed « D-Zug » express coaches, and in

1936 :

the first coaches of this new design with bogies having quadruple suspension.

For the arrangement of the fourth-stage suspension, first ideas were the same as for the insertion of the third (helical) axle spring. The very small forces set up during running, and caused by track irregularities, as well as vibration of the bogie frame caused by braking, reached the body without interruption, where they were felt as shudder. The purpose of the undamped helical springs inserted was to absorb these small forces.

In view of the small amount of available space and the area of the cross-section needed for the load, these springs, particularly on heavy saloon coaches, had to have a considerable diameter of spiral (255 mm [10″]) since the action of a spring is a function of the length of bar. Results were excellent, especially after the introduction of tyre coning ratios of 1 : 40/1 : 20. This was based on tests made by Oberreichsbahnrat Dähnick of the Berlin Central Management from 1928 to 1930, following the work of the « Commission to investigate running instability of express trains », and later, in 1933, with the first high-speed twin railcar of the « Fliegende Hamburger ». These tests included a detailed investigation into the relationship between rail and wheel after several years' running experience and wear.

Concurrent tests were undertaken with bolster suspension using helical springs and shock-absorbers. On the recommendation of the Carriage Testing Section, the shock-absorbers fitted were the « teleskop » oil type which had proved successful for special heavy coaches with three-axled bogies. Their general adoption for four-axled carriages was at first disliked because of the necessity during operation and maintenance for giving special attention to the oilfilled shock-absorbers.

The longitudinal reaction, which had long been observed and attributed to the influence of piston-engined steam locomotives, was overcome by increasing the longitudinal play of the swing bolster. It arose from the pitching oscillation of the bogie during running. Because of the small amount of play, only 2 × 1 mm (2 × 0.039″), between the swing bolster and the lower cross-bearer, the pitching of the bogie frame caused longitudinal oscillation of the bolster which resulted in longitudinal shocks in the body.

1937 :

Play of 2 × 5 mm (2 × 0.196″) was applied to the swing bolster of all types of bogie.

The year 1936 also saw the introduction on the Lubeck-Büchen Railway of double deck articulated coaches with Jakobs bogies of the Görlitz type. The end bogies were also of the Görlitz type.

For the measurement of oscillation, use

([11]) Dähnick : « Prüfung von Schweissverbindungen durch Dauerversuche » (Endurance testing of welded assembled) and « Prüfung zweckmässiger Schweisskonstruktion » (Objective testing of welded assemblies), June and November, 1936.

had so far been made of the old Dortmund oscillometer, which was not very handy, and also of the « Waas » type (recording one or several components of the movement) manufactured by the Askania Company of Berlin, which could be used for all measurements. The increased speed of passenger trains introduced in 1936, brought to the fore again the question of smooth running of coaches.

On the recommendation of the Carriage Testing Section, trials were undertaken with Grunewald type axleguards. The axles are guides without longitudinal play by means of rods, articulated at the frame without play or wear. This largely overcame the hunting or weaving (sinusoidal trajectory with a short length of wave) formerly occasioned by tyre wear.

The tyres of carriages fitted with axle guides and various types of suspension were in 1935-36 subject to service wear and careful measurements taken. Running quality trials took place on the circular route Lehrte-Brunswick East-Isenbuttel-Lehre. They illustrated the practical advantages of axle guides.

Following the trials with axle guides, other trials took place in 1937-38 with express coaches on the Erfurt-Weimar-Erfurt line. For a short time this was increased by the Sangerhausen-Sommerda section.

In 1937, Wumag of Görlitz produced

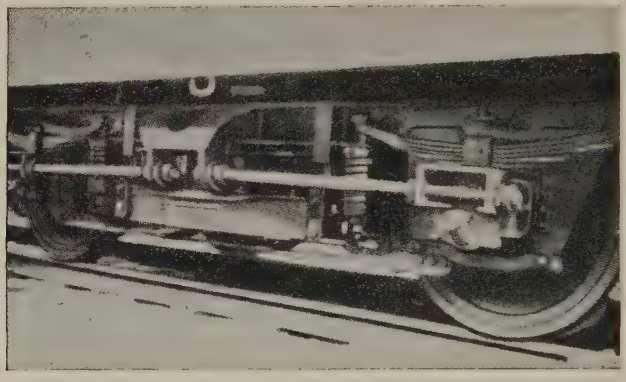


Fig. 16. — Rod type axle guide, Grunewald type.

Fig. 17. — Heavy Görlitz III bogie for saloon. and Mitropa coaches.

the first Görlitz bogie with dropped headstocks for the ferry-boat service with Denmak; it was possible to move under the body through 5° in the horizontal plan and 3.5° in the vertical plane, according to the arrangement on p. 126 of the axle load list (VAchsV) of 1937.

Munich, and compared. The experimental design recommended by Berlin subsequently became the normal type for all special coaches. This bogie can accommodate two nose-suspended lighting dynamos. The bottom portions of the solebars came down to the lower edge

Fig. 18. — Reichsbahn standard type bogie.

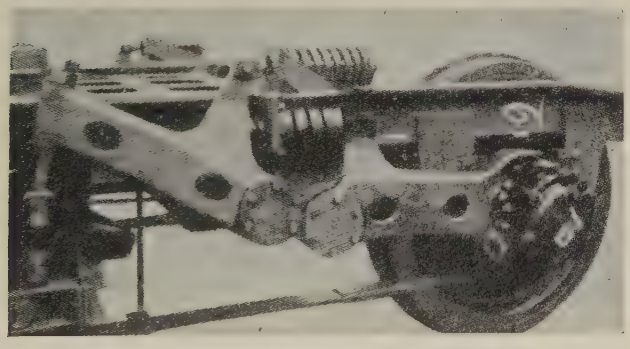


Fig. 19. — Bogie with torsion bar suspension.

At the same time, Wumag had also built the first special carriage bogies for ferry-boat traffic, based on the Görlitz III heavy type. For this purpose, an acceptable arrangement was arrived at only when, on the instructions of the Minister of Transport, heavy bogies had been designed in collaboration with the two central Administrations of Berlin and

of the axleguards which allowed an appreciable stiffening and strengthening of the frame. The Mitropa organisation subsequently ordered the construction of this type of bogie for its sleeping and restaurant cars.

1938 :

Wumag of Görlitz, Linke-Hoffmann of

Breslau and Orenstein and Koppel of Spandau designed and built light bogies for lightweight express coaches. Then, at the request of Dr.-Ing. Wiens of the Berlin Central Management, a standard light bogie was designed in collaboration with the firms mentioned above, the Vereinigte Westdeutsche Waggonfabriken of Cologne-Deutz and the Berlin Central Management, this bogie was built in 1940 by Wumag; it included for the first time hollow guides formed by two halves of pressed plate welded together, and a new axleguard stay link of Rellensmann type, which was put into service in 1941 for the bogies of all passenger vehicles.

In the meantime, the Sperling oscillometer, the main feature of which is variation by means of Foucault eddy-currents, had been sufficiently improved to be put into general use. The apparatus has been designed from the point of view of oscillations so that it allowed easy appreciation of the system used.

Also in 1938 appeared several new innovations :

The Talbot Company, of Aix-la-Chapelle, converted a Görlitz bogie for express coaches by using for the first time in railway service the torsion bar suspension already used on automobiles by Dr. Porsche. Helical springs in themselves are nothing but torsion bars, wound in a spiral to take up less space. The Talbot design did not bring any advantage, even when associated with axle drive and axles with free wheels. The design was not pursued.

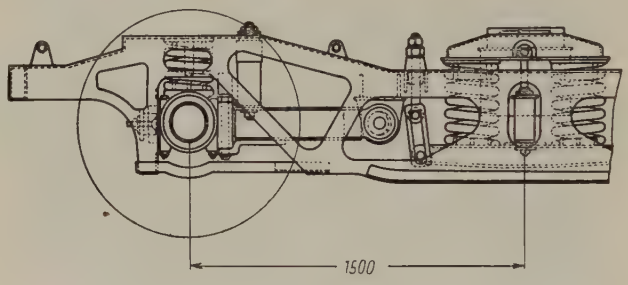


Fig. 20. — Proposed DR bogie designed by Berlin-Grunewald Carriage Testing Office.

Fig. 21. — Görlitz type three-axled bogie.

Moreover, a regulation issued in the same year specified that it should only be used roller bearings on new vehicles.

Finally, Reichsbahnamtmann Bernsdorf of the Postdam Workshops, proposed for the first time, the use of universally-adjustable bolsters to avoid wear resulting from insufficient lubrication. They were tried in the first place on heavy Mitropa and saloon carriages.

new bogie which, on the basis of his experience and existing technical knowledge, could be expected to provide the best running qualities and greatest freedom from wear.

1940 :

Wumag, developing the new service wagon type, offered a three-axled bogie for coaches of more than 64 tons, suspended

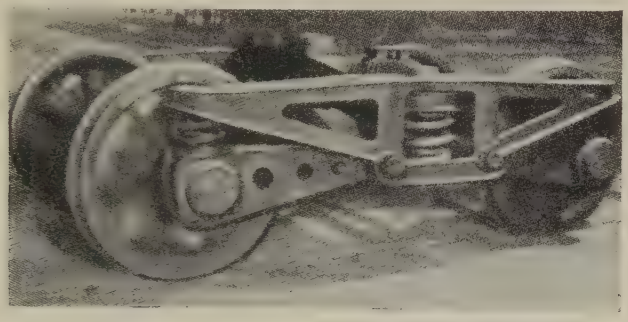


Fig. 22. — Bogie with radial axles.

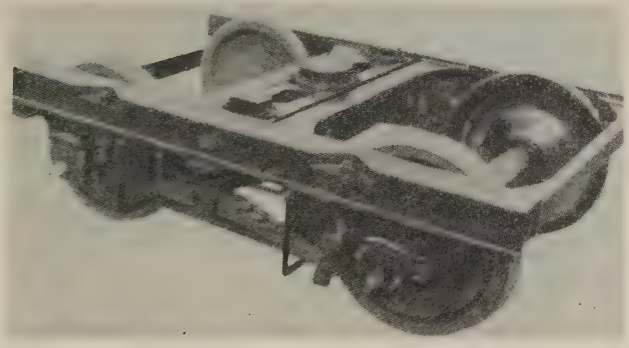


Fig. 23. — Krimml type bogie with rubber bolster springs.

Their general adoption was finally decreed in December 1940, and at the same time the adoption of synthetic washers and wearing discs for centre sockets to replace the packing lubrication then used.

1939 :

Dr.-Ing. Mielich, Chief of the Grunewald Carriage Testing Office designed a

entirely on helicoidal springs with oil-filled shock absorbers, which provided good running qualities. In the same year, Wumag proposed a modification to the centre of this bogie, to provide a pair of flangeless, unbraked wheels of smaller diameter (850 mm [33.4″] only). The bogie was subsequently built in this form for an observation car which did

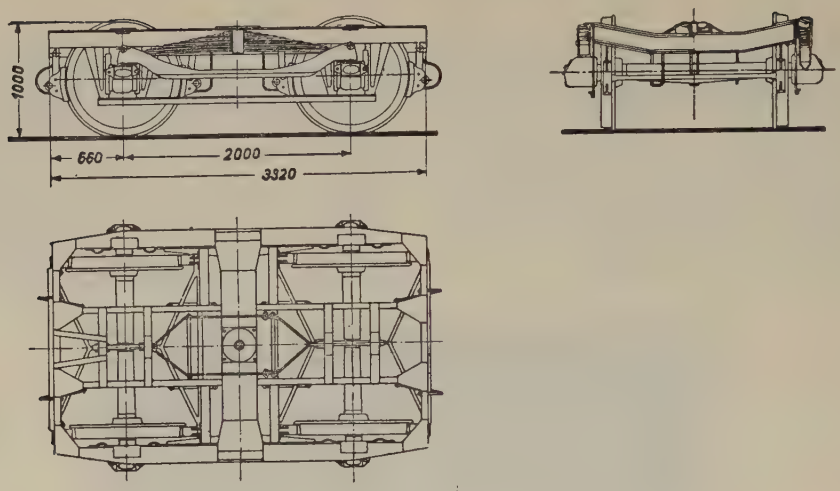


Fig. 24. — Standard bogie, using pressings.

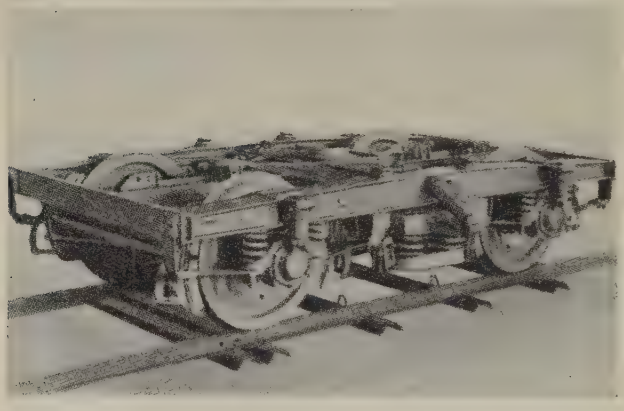


Fig. 25. — Minden-Deutz 50 type bogie.

not run satisfactorily and was very noisy with two-axled bogies. This three-axled bogie was also provided for special carriages with a weight equivalent to the loading limit for two-axled bogies, on which it was impossible entirely or adequately to suppress running noises by other measures such as insulation of wheel centres, use of non-metal centres or body insulation.

In the same year, 1940, Linke-Hoffmann of Breslau built various new lightened bogies for coaches of secondary lines and express trains. One of these had radial axles and did not give the results hoped for; the other had guided axles similar to the Görlitz types, with a low plate frame, wheelbase of 3 000 and 2 150 mm (118″ and 84.64″) combined laminated and helical spring suspension, as well as helical springs with oil dampers. These arrangements, however, con-

tributed nothing new and were not continued ([12]).

The only new project with double suspension and 2 000 mm (78.7″) wheelbase was the « Krimml » type. This designation was due to the fact that, following a foreign order for metre gauge, it was first built in Germany for a 760 mm (29.9″) gauge line from Zell-am-See to Krimml in the Pinzgau. The same type was subsequently used for 70 B4i carriages, normal gauge of 1 435 mm (56.3″). Whilst these narrow gauge vehicles, with four interior brake shoes, gave every satisfaction, the normal gauge type, probably because of the arrangement of helical axle springs on the axleboxes, at first gave very hard riding accompanied by hammer blows. When they were fitted with eight brake blocks the disadvantage was almost entirely eliminated.

This hard riding was also faintly noticeable with normal carriage bogies, having laminated and helical springs in series, when the brakes were applied; the axle oscillations were then transmitted via the brake rigging directly to the bogie frame and the bolster also bore against the longitudinal guides and caused wear.

1943 :

The standard « Reichsbahn » type was constructed in a simplified wartime design, using pressings. The expensive design, using welded plate was replaced by a cheaper type using rolled iron. The pressed plate guides were replaced by flat plate guides, gas-cut, and arranged end-on. The suspension was simple dual type, positioned axially below the solebars. Because of the lack of maintenance during the war, the guide fastenings had given way. For simplicity and economy, the guides were dismantled and the bogies returned to traffic with reduced longitudinal play.

In 1943, the removal of the restrictor chains, prescribed in 1861, was ordered because they could no longer fulfil their purpose of holding bogies in the track if they were derailed and so avoiding the train being telescoped, because of the high forces of inertia involved (high speeds and increased weights).

Also in the same year, to meet a recommendation of Professor Meinecke of the High School of Berlin, a bogie was built, similar to the English type built in 1901 by Breslau, in which the coach body was borne on the frame by way of the swing bolster and springs. In this bogie, the bearings take the full weight of the body and are located over the landings of the springs on the swing bolster. The lateral transoms had to be in the form of slipper plates. In addition, intermediate spherical bearings had to provide perfect rubbing surfaces. The ten sets of experimental bogies proposed were not constructed because of the events of the war.

1949 :

Based on the project of 1939, by Dr.-Ing. Mielich, already mentioned, the new « Minden-Deutz 50 » carriage bogie was built by collaboration between the Minden Central Administration and the « Westdeusche Wagonfabriken A. G. » of Cologne-Deutz ([13]).

The new bogie combined good running qualities with great strength, easy accessibility, simplicity in manufacture and low maintenance and workshop costs. The frame is of hollow beams, the suspension being simply of round-section helical springs with Teleskop oilfilled shock absorbers in parallel and flat axle guides. It had no axleguards. The axleboxes carry laterally, apart from the cast sockets for the axle springs, the rods for emergency axle control, which penetrate the solebars and serve to control the position of the axle in the event of the guides breaking.

([12]) v. Waldstätten : « Neue Drehgestellkonstruktionen » (New types of bogies), *Organ*, 1942, No. 6.

([13]) Körner : « Der Stand des Personenwagenbaues bei der Deutschen Bundesbahn » (Present position of carriage construction on the Reichsbahn), *ETR*, 1952, No. 3. — Dr.-Ing. Mielich : Several publications. — Paul : *Der Eisenbahner*, Starnberg, 1953, No. 6-7.

[625 .142 (54)]

Conversion of unserviceable BG steel trough sleepers into narrow gauge sleepers.

Describes a technique for converting discarded broad gauge steel sleepers into narrow gauge sleepers in an ordinary engineering workshop without special machinery,

by N.S. Tyabji,
Deputy Chief Engineer, Eastern Railway,
and C. Rozario,
Workshop Engineer, Sini, Eastern Railway.

(From *Indian Railway Technical Bulletin*, August 1955.)

Eastern Railway (Ex. B. N. Zone) had many thousands of unserviceable steel trough sleepers previously used with 75 lb. rails lying in Khargpur Scrap Yard and with the Open Line Districts. The sleepers were generally found to have cracks under the rail seats leaving a portion between the inner lugs of the sleepers measuring 5′-5″ in the middle which could be salvaged in almost every case; it was decided therefore to utilize the large number available to make narrow gauge sleepers out of the middle good portions that could be salvaged from the condemned B. G. sleepers.

In the absence of proper equipment in a small workshop like Sini, it was difficult to start manufacture of the sleepers straightaway. The greatest diffilculty was the lack of a heavy press for punching the sleepers. However, the following machinery was available :

a) A friction disc-saw for cropping off the two ends of the unserviceable sleepers very economically;

b) A screw press to give the necessary 1 in 20 cant to the sleepers using a cast iron block former;

c) A 15 cwt. drop stamp for shaping both the ends also using cast iron block formers;

d) For punching the four $^{3}/_{4}''$ square holes and the 2′-3″ long lugs at one stroke on sleepers varying in thickness from $^{1}/_{4}''$ to $^{3}/_{8}''$, two types of machines were available :

i) the standard Henry Pells Shearing and Punching Machine which could punch only one hole at a time, and

ii) the 56-ton rivetting machines.

The Mills hydraulic rivetters were tried out first, as these were new machines. Sleepers had to be heated before punching as the power required varied from 30 to 50 tons according to the thickness of the sleepers when punching in cold. But these machines had to be abandoned as the return stroke of the ram was not powerful enough to take the punching tool out of the punched hole after the stroke was completed. Finally, therefore, the old Leipziger Electro Mechanical Rivetters were tried out. These machines had mechanical return stroke as powerful as the forward stroke, and so proved suitable.

Another difficulty was that the dies and punches made out of plain carbon tool steel generally used in the Workshop could not stand the punching in red heat. So after a few trials it was found necessary to indent for special Hot Die Steel to

D. G. M. P. Class II (Tool Steel) from Khargpur. This steel gave quite good results after proper heat treatment. Its typical composition is given below :

C.	Si.	Mn.	S & P
·25/·30	·35 max.	·26/·35	less than ·03

Ni.	Cr.	V.	W.
·8/·9	3·5/4	0·4	8/10

Special precautions had to be taken while forging this steel, for if the temperature was allowed to fall below 850° C while forging, internal cracks developed in the steel. Annealing, hardening and tempering were done as usual.

Plate 2 shows the rivetting machines which are tall and slender, and can be handled easily by overhead cranes for placing in any convenient position for rivetting girders, & c. Two such rivetters, each designed to developed 56 tons, were bolted on to a 2″ thick plate at a distance of 2′-9 $^1/_2$″ centres. Then the punches were fixed on two fabricated steel boxes and the boxes fixed on to the rams of the rivetters by cotters. The boxes were guided by channels fixed on the 2″ thick plate on which the rivetters were bolted.

At the start the required lug to lug distance of 40″ was increased by $^3/_8$″ to allow for contraction caused by the expansion of the steel at red heat. But after punching a few sleepers it was seen that about $^1/_8$″ extra contraction took place and so this had to be added to the distance between the lugs. There was no pyrometer for checking the exact temperature, but the blacksmith was sufficiently good at judging the correct temperature, so much so, that in almost every case the gauge was correct, showing that the contraction was uniform. Now the two machines with two independent prime movers had to be synchronized to work together, so the operating handles of both the machines were connected together and both sides of the sleepers could be punched in one stroke.

The manufacturing process was organized as shown pictorially in plate 1 and described below.

The unserviceable sleeepers as they were received from the reclamation yard or from the Open Line Districts were unloaded near the Friction Saw. Here then ends of the unserviceable sleepers were cropped off. The two ends of approximately 80 sleepers could be cut off in the Friction Saw in an 8- h shift. The Friction Saw has a low carbon alloy steel disc of 46″ dia. when new, rotating at a speed of 2 000 r.p.m. It was supplied by Messrs. Clifton & Baird Ltd. and is worked by 35 HP Electric Motor; it cuts M.S. Sections of any shape and size very quickly by the heat produced due to the friction between rotating disc and the material being cut.

After the ends of the unserviceable B. G. steel trough sleepers were cropped off by the Friction Saw, the sound middle portion about 5′-5″ in length were taken to furnace No. 1. This furnace was specially made to heat the two ends of the cut sleepers. The length of the furnace was about 31 ft. with grating only about a foot wide. 25 pigeon holes were made along the length of the furnace to accommodate 25 sleeper ends to be heated at a time, so that ends could be cupped in the drop forge in a continuous operation.

After the ends were formed by the Drop Stamp, the sleepers were passed on rollers to Furnace No. 2. This furnace had a grate area suitable for heating about 10 full sleepers at a time. The sleepers were heated to red heat (about 800° C) and were then passed on rollers to the screw press to get the required cant of one in twenty. About 6 men were required to operate this press.

From the screw press, the sleepers were taken on rollers back to furnace No. 2 for reheating to dull red, about 600° C, and then on to the machine for punching the four square holes and the two lugs.

At the start the reheating was omitted and the punching was done at about

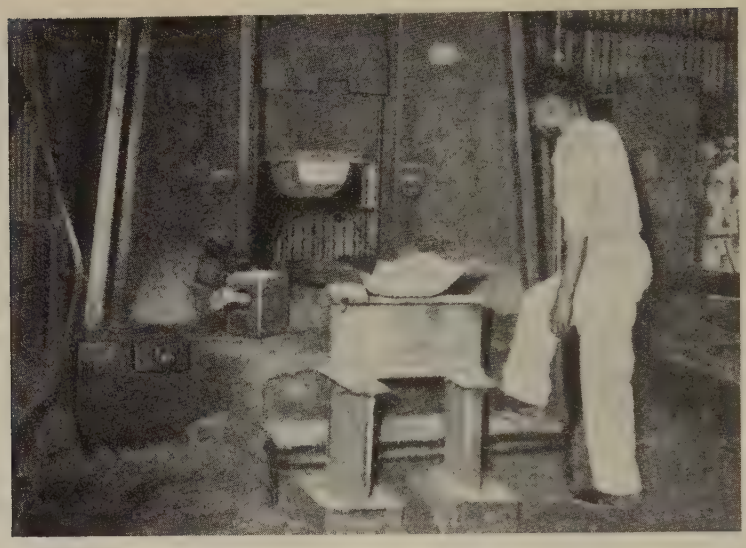


Fig. 1. — Cupping the ends of the cut sleepers in the 15 cwt. drop stamp.

Fig. 2. — Heating the sleepers prior to pressing in screw press.

300° C to 400° C after the pressing. However, this caused an overloading of the punching machine which started giving trouble.

As furnace No. 2 is not conveniently sited for the reheating, a new furnace No. 3 has been constructed to reduce the operation time and to prevent a clash between

Fig. 3. — Shaping the sleepers in the screw press to give the cant.

Fig. 4. Checking gauge and cant.

the sleepers being reheated for pressing and those being reheated for punching.

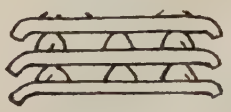
After punching, sleepers meant for areas where there is likelihood of corrosion are rolled into throughs containing hot tar and then stacked for cooling.

Generally however the sleepers were left untarred and after cooling in the atmosphere, checked for gauge and cant as per Plate No. 3.

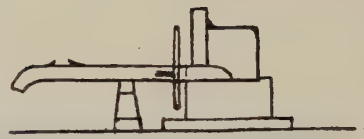
The clips for fixing the rails to the sleepers were cast and drilled in the work-

EASTERN RAILWAY MANUFACTURING PROCESS
FOR CONVERSION OF 75 LBS
B. G. SLEEPERS INTO - N. G. SLEEPERS.

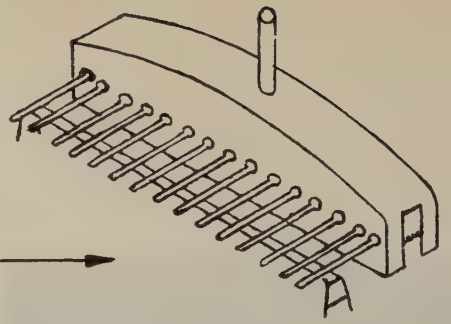
PLATE 1.



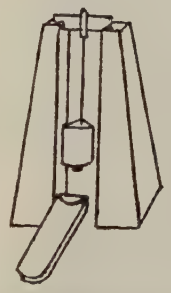
Stack of U/S 75 lbs steel sleepers.



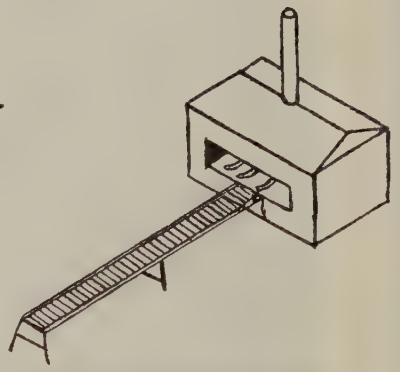
Friction disc saw.



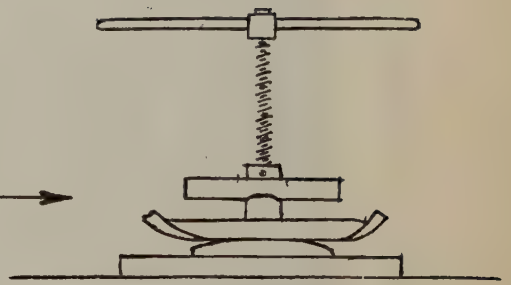
Heating the ends of cut sleepers.



Shaping the ends by the massey drop stamp.

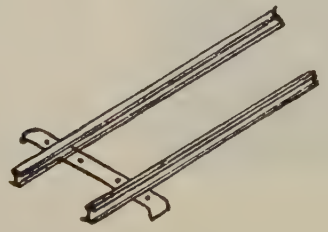


Heating sleepers for pressing.

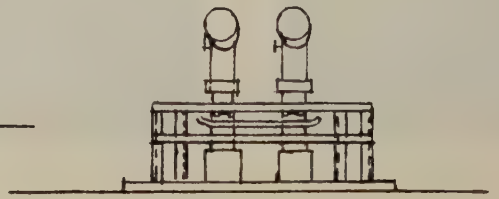


Screw press for giving cant.

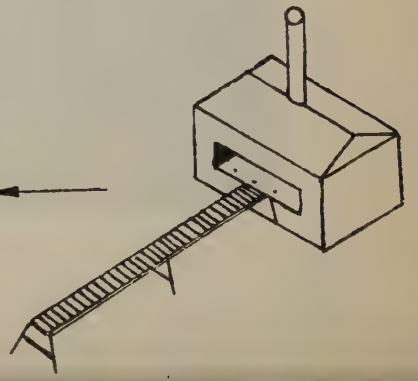
To stack.



Checking gauge and cant.

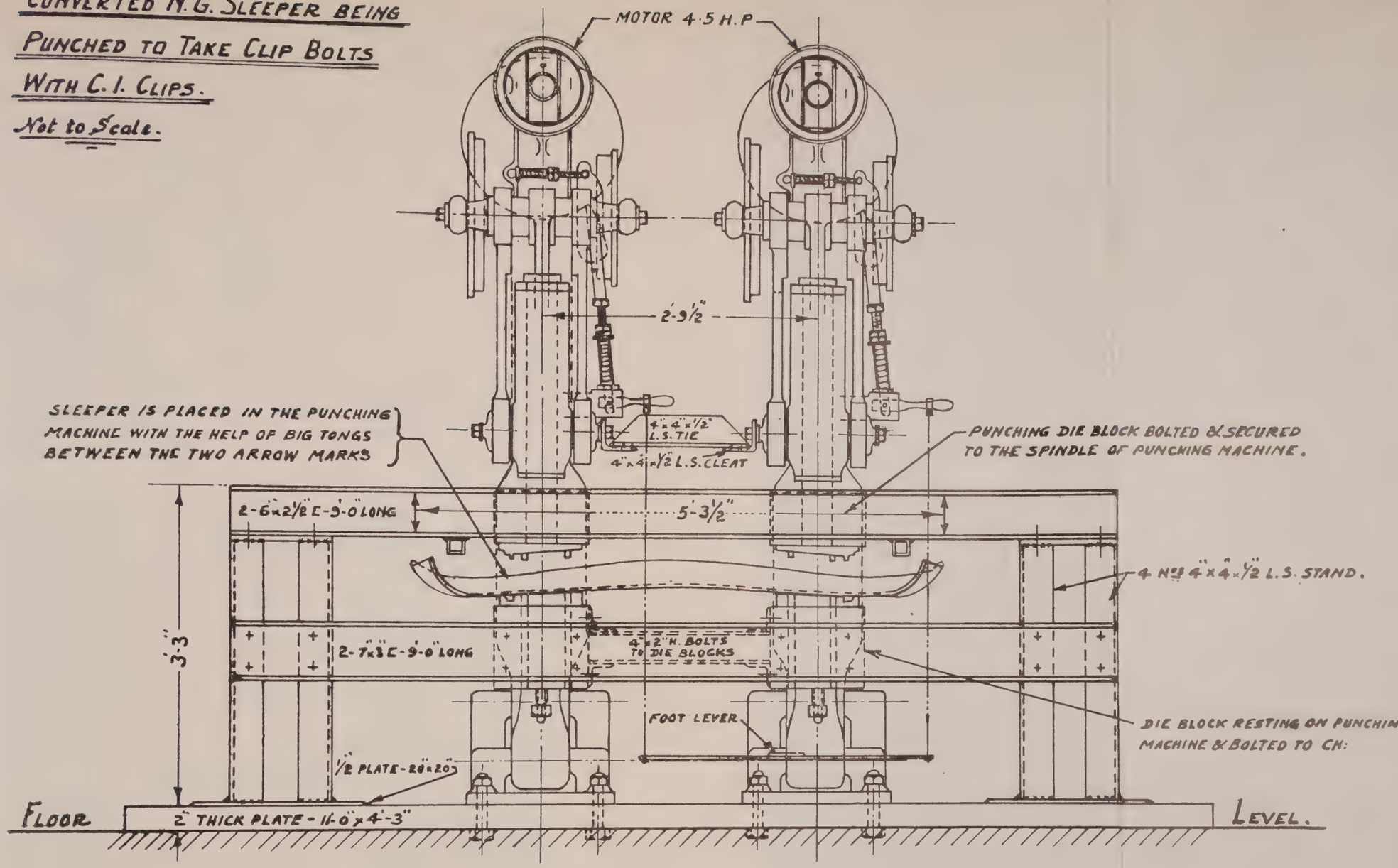


Punching sleepers.

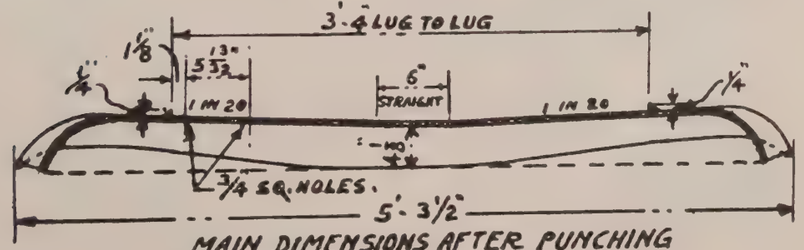


CONVERTED N.G. SLEEPER BEING PUNCHED TO TAKE CLIP BOLTS WITH C.I. CLIPS.

Not to Scale.


MOTOR 4·5 H.P
2'-9½"
SLEEPER IS PLACED IN THE PUNCHING MACHINE WITH THE HELP OF BIG TONGS BETWEEN THE TWO ARROW MARKS
4"x4"x½" L.S. TIE
4"x4"x½" L.S. CLEAT
PUNCHING DIE BLOCK BOLTED & SECURED TO THE SPINDLE OF PUNCHING MACHINE.
2-6"x2½" C-9'-0" LONG
5'-3½"
4 Nos 4"x4"x½" L.S. STAND.
3'-3"
2-7"x3" C-9'-0" LONG
4"x2" H. BOLTS TO DIE BLOCKS
FOOT LEVER
DIE BLOCK RESTING ON PUNCHING MACHINE & BOLTED TO CH:
½" PLATE-20"x20"
FLOOR
2" THICK PLATE - 11'-0" x 4'-3"
LEVEL.

FRONT VIEW OF TWO "LEIPZIGER" ELECTRIC PUNCHING MACHINES COUPLED TOGETHER FOR PUNCHING SLEEPERS.



MAIN DIMENSIONS AFTER PUNCHING

Sd/-
WORK-SHOP ENGINEER,
E. RLY SIND.

CAST IRON REVERSIBLE CLIPS FOR 41 LBS & 50 LBS RAILS

SCALE :- FULL SIZE

FIG 1

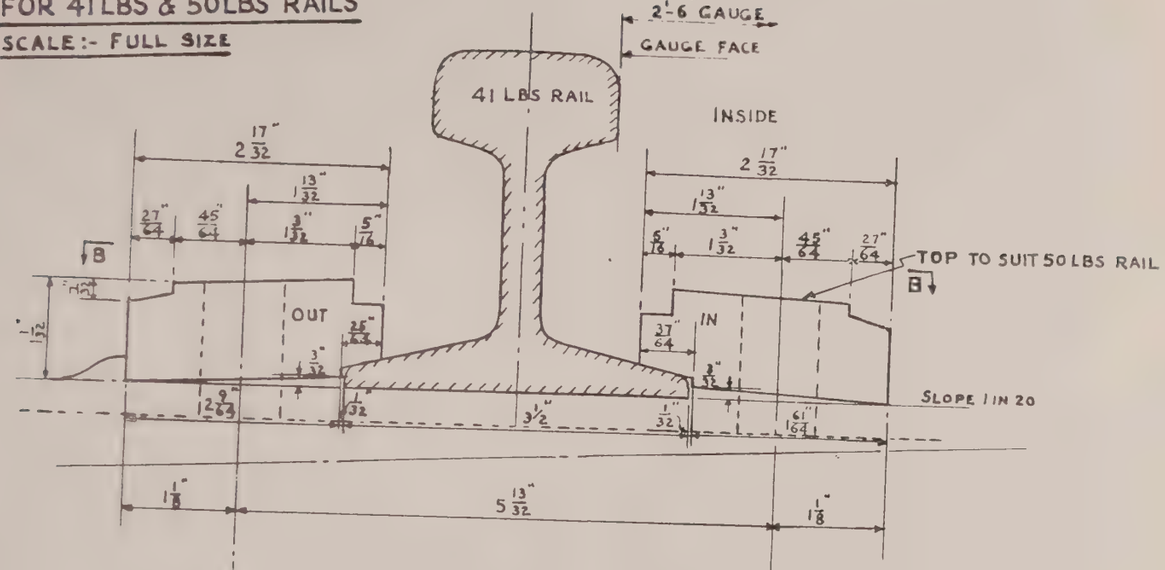
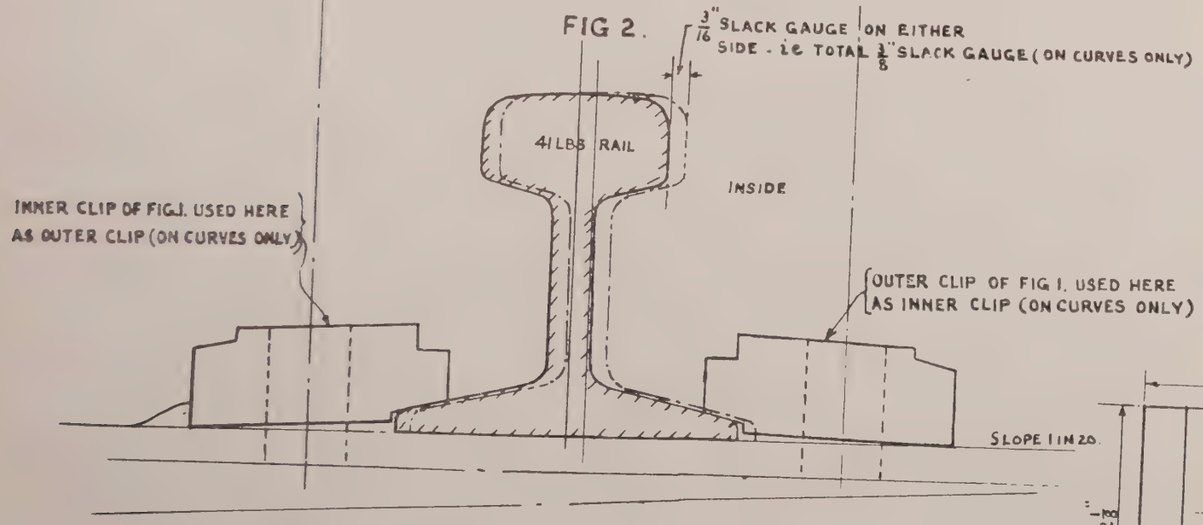


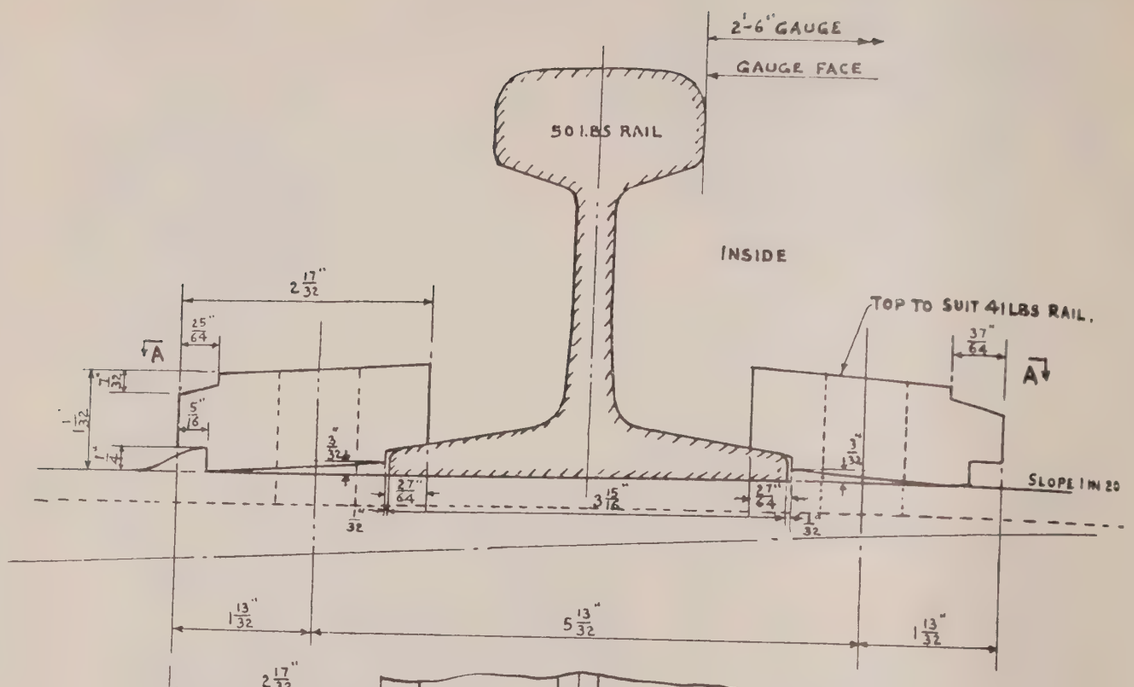
FIG 2.

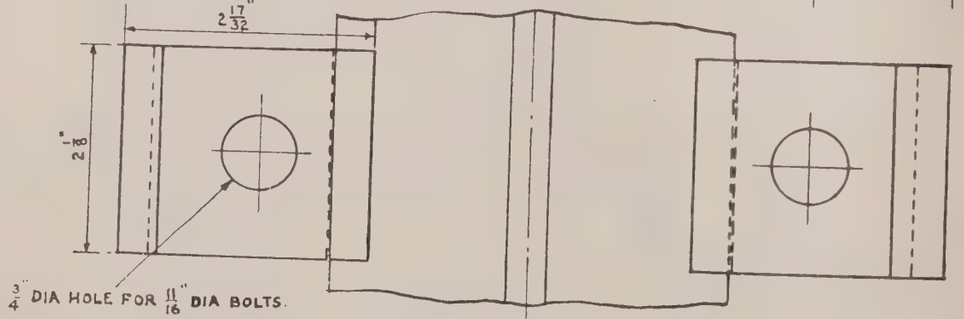

3/16" SLACK GAUGE ON EITHER SIDE - ie TOTAL 3/8" SLACK GAUGE (ON CURVES ONLY)
41 LBS RAIL
INSIDE
INNER CLIP OF FIG 1. USED HERE AS OUTER CLIP (ON CURVES ONLY)
OUTER CLIP OF FIG 1. USED HERE AS INNER CLIP (ON CURVES ONLY)
SLOPE 1 IN 20.

NOTE :-

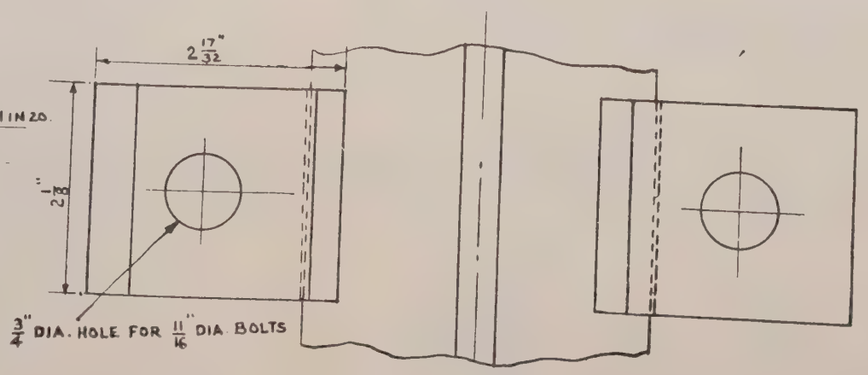
1. RAIL IN CHAIN DOTTED LINE SHOWS RAIL IN STRAIGHT PORTION WITH IN & OUT CLIPS AS SHOWN IN FIG 1.

2. RAIL IN FULL LINE SHOWS RAIL IN CURVE PORTION USING INNER & OUTER CLIPS OF FIG 1 AS OUTER & INNER CLIPS IN FIG 2 IN DOING SO ON EITHER SIDE A SLACK GAUGE TO THE EXTENT OF 3/8" IS OBTAINED.





SECTION ON A.A.

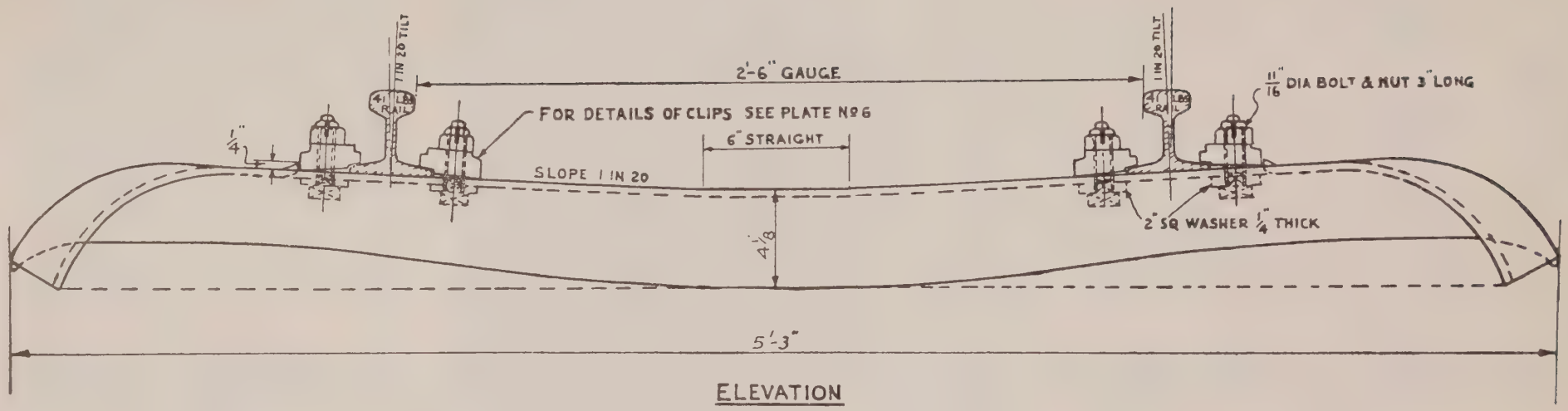


SECTION ON BB

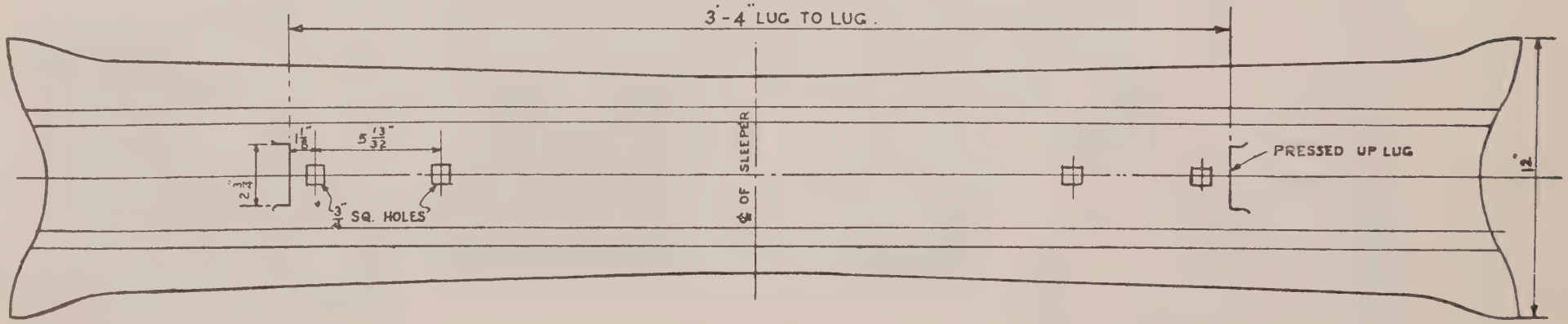
UNSERVICEABLE B. G. STEEL TROUGH SLEEPER

CONVERTED TO N. G. SLEEPER.

Scale : 3″ = 1′ 0″.



ELEVATION



shop to suit both 41 lb. and 50 lb. rails. The clips had only to be reversed to get the different sections in gauge, the inner and outer clips remaining in their relative positions. The arrangement is shown in Plate No. 4.

The bolts and nuts were received from the Reclamation Yard, Khargpur, and reconditioned in the workshop for the first 20 000 sleepers.

Thus the manufacturing process, though rather crude, is quite efficient, producing about 125 to 130 sleepers per 8-h shift.

Staff organisation.

The staff engaged was all casual, at open market rates. Work was done in two shifts, each shift being managed by a mistry assisted by a few blacksmiths, fitters and machine operators. The rest were all khalasis. Distribution of staff is shown below :

1) Scrap Yard : Six Khalasis for bringing sleepers;

2) Friction Saw : One semi-skilled operator and 4 Khalasis;

3) Furnace No. 1 : One semi-skilled operator and 12 Khalasis;

4) 15 Cwt. Drop Stamp : One semi-skilled operator and 2 Khalasis;

5) Furnace No. 2 : One skilled blacksmith and 8 Khalasis;

6) Srew Press : Six Khalasis.

7) Punching Press : One skilled operator and 4 Khalasis;

8) Stock Yard : Six Khalasis;

9) Checking : One skilled fitter and 2 Khalasis.

Thus, altogether one mistry, three skilled men, three semi-skilled men and 50 Khalasis were engaged to produce 125 to 130 sleepers per shift.

Cost.

So far 20 510 sleepers have been produced at the total cost of Rs. 1.69.134-13-0.

The total cost included the following at casual rates of Rs. 38, Rs 65 and Rs. 100 for unskilled, semi-skilled and skilled staff respectively :

	Rs.	a.	p.
1) Direct Labour charges	39 995	14	0
2) Material charges including scrap value of unserviceable sleepers and clip bolts	76 603	7	0
3) On-cost charges (*a*) 140 % on labour	52 535	8	0
	1.69 134	13	0

Under item 2 « material charges » is included the cost of unserviceable steel sleepers at Rs. 2 each, allowing for return value of cut ends, reclaimed clip bolts with nuts at annas 4 each, C. I. clips manufactured at Sini at a cost of annas 5 and 6 pies per clip, and a total of Rs. 972 for the initial cost of furnaces for heating of the sleepers.

Thus the cost per sleeper including all fittings came to about Rs. 8-4-0. This is definitely cheaper than the market rate where an I. R. S. Type 2'-6" gauge steel sleeper for the 50 lb. section rail complete with fittings is priced at over Rs. 10. These converted sleepers have the additional advantage that both 41 lb. and 50 lb. section rails can be used; the weight and width of the sleepers are also greater, giving better stability and longer life.

Acknowledgement.

The photographs reproduced here were taken by the staff photographer of the Public Relation and Publicity Office for Railways in Calcutta with the kind permission of the Officer in Charge.

[621 .132 .3 (42)]

« Merchant Navy » class Pacific modified.

(*The Railway Magazine*, April, 1956.)

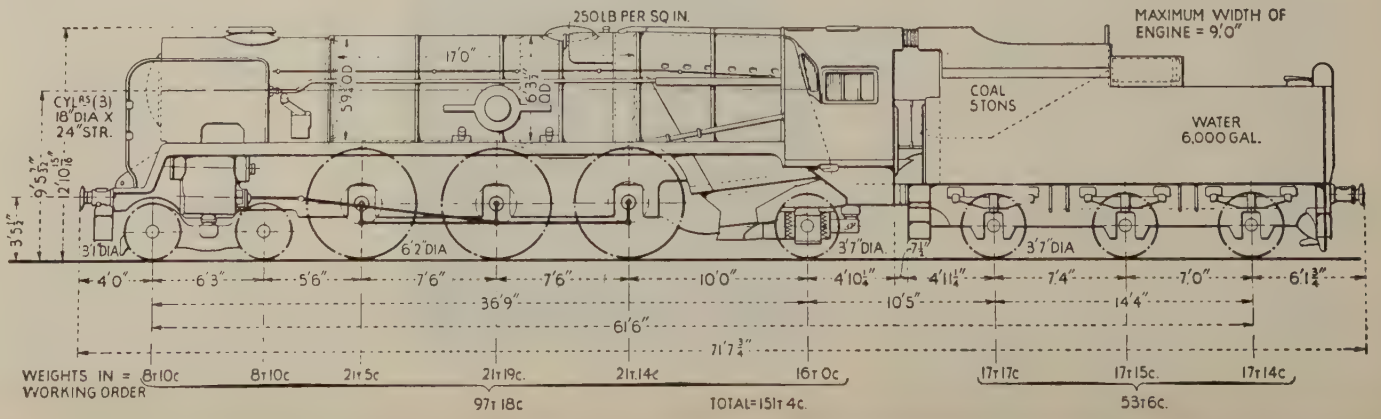
The first of the Southern Region « Merchant Navy » class 4-6-2 locomotives to undergo extensive modification, No. 35018, *British India Line*, has emerged from Eastleigh Works. Initially, it is intended that a further 14 will be similarly rebuilt, followed by 15 of the smaller « West Country » Pacifics.

No. 35018, « British India Line », leaving Eastleigh with the 12.23 p.m. train to Southampton Central on February 17, the first passenger working after it was rebuilt.

The « Merchant Navy » class locomotives were introduced on the Southern Railway in 1941, to the designs of Mr. O. V. S. Bulleid, then Chief Mechanical Engineer. Thirty in all were built at Eastleigh, in three batches, the last in 1949. When in good condition, they have displayed complete mastery of their work on principal expresses to Bournemouth and the West of England and on boat trains to the Channel Ports.

Although the locomotives follow the normal design tendencies for a Pacific type with three cylinders and a wide firebox, there are a number of features unusual in British locomotive practice, among which are : *a*) A three-throw crank shaft, chain-driven from the driving axle, which operates valve gear for each of the three cylinders. Each gear is connected to its respective piston valve through a rocking lever arrangement having a 3 : 8 ratio; *b*) An oil-bath enclosing the three sets of special valve gear and the inside motion. This is intended to give continuous lubrication

General view and diagram giving principal dimensions and axle loads of modified « Merchant Navy » class 4-6-2 locomotive.



to the working parts; *c*) A smokebox of irregular shape; and *d*) Light plate casing over the whole of the upper part of the locomotive. Some of these features have proved troublesome, with the result that the locomotives have not been entirely satisfactory from the point of view of availability, maintenance and accessibility. In addition, their consumption of coal, oil and water is high in comparison with other modern locomotives.

Various minor modifications have been made since the design was introduced, but to overcome these difficulties certain fundamental alterations were decided on, in accordance with designs prepared at Brighton under the direction of Mr. H. H. Swift, Chief Mechanical and Electrical Engineer, Southern Region, in consultation with, Mr. R. C. Bond, Chief Mechanical Engineer, British Railways Central Staff, British Transport Commission. The work of preparing the new details was carried out mainly at Eastleigh, with assistance from Ashford Works.

The three-cylinder arrangement is the same on the modified locomotive, with the cylinders in their former positions, driving on to the middle coupled axle. A new inside cylinder is provided, but the two existing outside cylinders have been retained. The diameter and stroke are unchanged at 18 and 24 in. respectively, and the piston valves remain at 11 in. dia. The inside cylinder has the steam chest offset to the right, and in common with normal modern practice has inside admission. A steel casting, having cast-iron liners to both the cylinder barrel and steam chests, has been used, to save weight.

The valves of the outside cylinders were formerly driven indirectly by a rocking shaft from the valve gear, passing into the exhaust chamber of the steam chest, an arrangement which permitted the use of outside admission. The steam chests, moreover, are placed on the same vertical centre line as the cylinders. To avoid replacement of the outside cylinders, it has been necessary to retain the latter feature and also outside admission. This has necessitated the use of a high-pressure gland for the valve spindle, and special measures to translate the actuation from the plane of the valve gear to the steam chest centre line.

Following the latest British Railways practice, the piston heads are attached to the piston rods by a parallel fastening. The piston rods are provided with a special type of cast-iron packing, and this packing is also used for the valve spindles of the outside cylinders. Cylinder cocks are of the steam-operated type.

The incorporation in the original design of continuous lubrication to the motion between the frames is an ideal principle, but in practice the oil-bath has been only partly successful and has brought troubles of its own. These were, broadly, excessive use of oil because of practical difficulties in keeping the bath oil-tight, the entry of water causing emulsification of the oil and corrosion of the steel motion details, and the inability to examine the various working parts except at infrequent intervals. As a result, it has been decided to dispense with the oil-bath and return to the orthodox arrangement in which the motion and valve gear of the inside cylinder are not completely enclosed, and require the normal attention as regards examination and lubrication.

Three independent sets of Walschaerts valve gear are provided, those for the outside cylinders being driven by return cranks placed on the driving crankpins, and by crosshead arms attached to the crossheads. The latter had to be redesigned for this reason and, as the original piston rod and crosshead had been manufactured from a single forging, the opportunity was taken with the new crosshead of making it separate from the piston rod, the normal cone and cotter attachment being used.

The outside valve gears, being arranged for outside admission, transmit the mo-

tion to the valve spindle from the top of the combination lever, but because of the offset between the centre line of the valve gear and the axis of the steam chest a suspension link is used, which carries the weight of the valve gear, thereby eliminating the need for the normal valve spindle crosshead guides. A short link connects the suspension link to the valve spindle crosshead. The piston valves have a maximum travel of nominally 6 3/4 in., and each head is fitted with four narrow rings. The return crank rod is attached to the return crank through a self-aligning ball bearing.

The inside valve gear is driven by an eccentric mounted on the right-hand crank-web of the driving axle. A spigotted attachment held by five studs is used, and the mounting for the eccentric is interchangeable with that of the chain-drive sprocket of the former valve gear when applied in its latest form. The new valve gear is of orthodox design, being arranged for inside admission. The lap-and-lead motion is driven in the normal way from an arm made integrally with the crosshead. The maximum travel is approximately 6 5/16 in.

The steam reversing gear has been dispensed with and in its place a screw gear has been provided. To suit the layout of the locomotive, the arrangement selected is one in which the cab contains only the handle, spur gearing, locking gear and cut-off indicator. The operation is transmitted by means of a shaft, with universal joints, to the screw located on a bracket attached to the outside of the main frame, midway between the lefthand driving and trailing wheels. A short bridle rod connects the reversing screw nut to the reversing shaft. This arrangement, which is a compromise, between that in which the screw is mounted in the cab, and that in which it is placed directly at the reversing shaft, was first used on the London, Midland & Scottish Railway.

Normally with three or four cylinder locomotives which have independent sets of valve gear, it is necessary to use an auxiliary reversing shaft for the inside valve gear. In this case, however, it has been found possible to use a single shaft for all three gears, lifting of the radius rods being achieved by the arrangement in which a slide block works in a slot in the radius rod, the former being attached directly to the reversing shaft arm. The handle in the cab is « face-on » to the driver, and the cut-off indicator is of the drum type.

A new smokebox of the orthodox cylindrical shape is provided and this rests on a saddle, part of which is formed by the upper portion of the new inside cylinder and the remainder by a new fabricated saddle-stretcher. The latter is bolted to the front of the cylinder casting as well as to the frames, and, as it spans the space between the two outside cylinders, it gives a greater degree of rigidity to the front end of the locomotive. The saddle-stretcher is designed in such a way that it permits of ready access to the front cover of the inside cylinder and for the removal of the piston and rod. By removing a cover plate on the top of the stretcher, inside the smokebox, the inside valve spindle can be withdrawn.

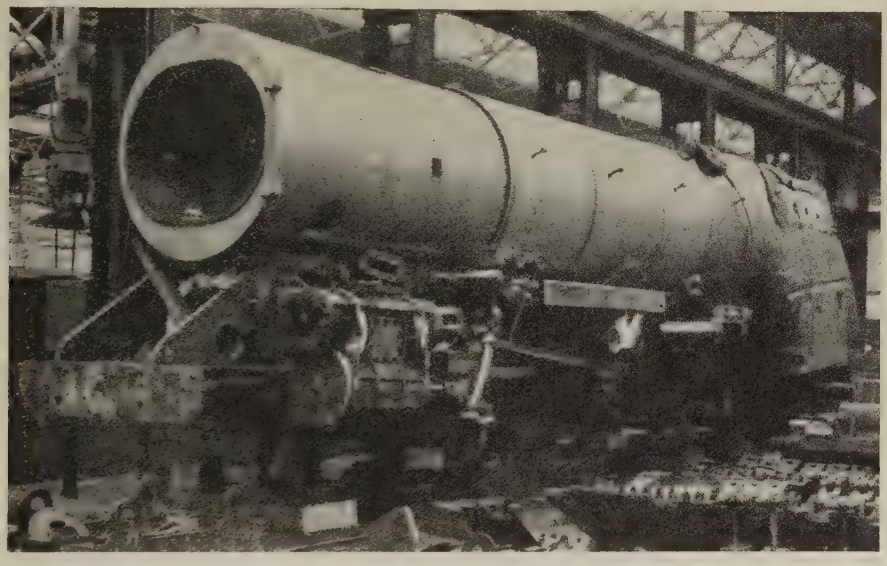
The smokebox is surmounted by a cast-iron chimney of large diameter fitted with a petticoat and ejector exhaust ring. The multiple-jet blast-pipe is retained. A new superheater header has been fitted which has three flanges for individual steam pipes to each cylinder. The right-hand outside flange takes the steam pipe to the inside cylinder, while the inside and left-hand flanges feed the right-hand and left-hand outside cylinders respectively. All three steam pipes pass outside the smokebox through stuffing boxes on the smokebox wrapper. The existing smokebox door of elliptical shape has been retained.

The air-smoothed casing which formerly enveloped the boiler and smokebox has

been dispensed with, and replaced by orthodox boiler clothing plates mounted on crinolines The smokebox is unclothed. Footplating along the sides of the engine has been provided to assist in servicing and maintenance, following the pattern of the B. R. standard locomotives, except that it is carried principally by brackets from the main frame. A smoke deflector plate is provided at each side of the smokebox.

ment for fire cleaning while running, and a large movement for dumping when the locomotive is over the ashpit. An entirely new ashpan is fitted; it has the standard type of butterfly doors for self-emptying. These are operated from the ground by a common linkage to a short lever which takes the same bar as that used for operating the rocking grate.

A feature of the previous ashpan which is retained is its division into three parts,



No. 35018 undergoing modification in Eastleigh Works on January 21.

The boiler is unaltered, but, to bring the locomotive up to the latest standards, in the interests of good combustion and rapid turn-round, it is fitted with a rocking fire-grate of the standard type. The rocking sections are divided into two groups which can be rocked separately and are situated on each side of the longitudinal centre line. Both groups comprise six carrier bars, each mounting fifteen unit firebars. Two extents of rocking are provided for by locking devices incorporated in the operating gear on the footplate — a small angular move-

there being a central section between the frames, and two outer sections. The former has two hoppers, each with bottom doors, the rear leg passing through the reins of the trailing truck. Two damper doors are provided in the central section, the forward door being hinged from the front leg and the trailing door from the rear leg. The outer sections of the ashpan have one hopper each, in line with the front leg of the central section, the rear portion of these pans being situated, inevitably, above the wheels of the trailing truck. To enable this por-

tion to be cleaned out where it is not possible to provide sufficient slope to ensure that the ashes will slide down normally, side access doors are provided so that any accumulation of ash can be rodded down at disposal.

Two damper doors are provided on each of the outer sections of the ashpan so that, in all, there are three damper doors facing forwards and three facing rearwards; this provides adequate combustion air to support the highest steaming rate of which the boiler is capable. The damper doors are operated in two groups by screw control on the footplate. The transverse shaft which operates the three forward doors, which are in line, is provided with a simple form of universal joint so that any slight deformation of the ashpan will not cause tightness.

The structure of the cab is unaltered except that, for accessibility and to conform with the altered external appearance of the locomotives, the lower portion of the curved side sheeting is cut away. The new cab roof ventilator provided is of a type supported on links, so as to be easy to operate and positively held.

The majority of the driving controls remain the same, the principal exception being the provision of the reversing screw handle and gearbox in place of the controls to the steam reversing gear. This alteration has made it necessary to adjust the driver's seat to a position slightly further back. The same type of firehole door is retained, but as the steam operating gear is very little used this has been removed. The firehole is fitted with a deflector plate to improve the combustion of the volatile content of the coal, by directing the secondary air into head-on collision with the gases leaving the fire-bed.

The cylinders and steamchests are fed by three six-feed mechanical lubricators, which were formerly mounted on the platform in front of the smokebox. The new position is on the side footplating immediately above the slidebar brackets. Two of the lubricators are located on the left-hand side and the third, together with a new ten-feed lubricator for engine oil, is on the right-hand side. They are driven in the normal manner from small levers attached to the outside expansion links.

Lubrication to the steam chests of the outside cylinders is atomised, but atomised feeds to the inside valve are introduced into the steampipe, because of the position of the steam chest under the smokebox. The cylinder barrels are lubricated by non-atomised feeds introduced at top and bottom. The remaining non-atomised feeds are to the piston rod packing and the valve spindle rear bush.

The coupled axleboxes are fed at the crown by feeds from the engine oil mechanical lubricator, and this eliminates the large multi-feed oilboxes previously fitted in the cab. The remaining feeds from the lubricator supply the slidebars and the inside valve spindle crosshead guides. Small auxiliary oilboxes with trimming feeds supply the axlebox guides and also the piston rod swab-boxes. The connecting and coupling rods are, as previously, oil lubricated, but the majority of the valve gear is lubricated by grease.

As built, the locomotives had steam sanding for forward running applied to each coupled wheel. For backward running, two sandboxes were fitted to the front of the tender to give dry sanding on the rail between engine and tender. The sandboxes for the leading coupled wheels formed a part of the smokebox, while those for the driving and trailing coupled wheels were disposed under the casing, along the side of the boiler. The leading sanding gear gave rise to difficulties and was subsequently removed.

In the modified locomotive, the leading sanding gear is restored and the sandpipes which formerly led to the trailing coupled wheels are reversed to provide sanding behind the driving wheels for

rearward running. The sandboxes on the tender have been dispensed with. Because of the re-design of the smokebox and the removal of the casing, it has been necessary to provide entirely new sandboxes. The leading boxes are placed on the platform adjacent to the rear of the smokebox. The boxes for the driving pair of wheels are placed between the frames : a twin box ahead of the crank axle for the forward, and a similar box behind the crank axle for the rearward sanding gear. These boxes have extensions to the footplating on each side of the engine for filling purposes.

The engine and tender drawbar is pin-jointed at the tender end to a plunger which slides in guides and is controlled by the drawbar rubber spring in such a way that the tractive force is cushioned by the spring. In the static position the engine and tender are held positively at their correct distance by curved rubbing blocks on the engine and tender drag-beams. The curves are struck from the centre lines of the corresponding drawbar pins, so that any movement between engine and tender is accomplished without additional loading of the drawbar and spring. The rubbing blocks are faced with manganese steel to reduce wear.

The superstructure of the tender is modified by the removal of the side raves, and compartments for the fire-irons are formed on each side of the coal bunker. A casing is placed over the vacuum reservoirs to prevent their becoming enveloped in coal. The rear portion of the tender top is flat and open so as to facilitate the manipulation of the water crane. The tank is provided with external feed sumps with shut-off valves to enable the sieve contained in them to be removed and cleaned without the necessity for emptying the tank. A float type of water level indicator is provided.

Principal particulars of No. 35018 are as follows :

Cylinders (3), dia. and stroke	18 × 24 in.
Wheels :	
Coupled, dia.	6 ft. 2 in.
Bogie, dia.	3 ft. 1 in.
Trailing, dia.	3 ft. 7 in.
Heating surface :	
Tubes	2 176 sq. ft.
Firebox (incl. syphons)	275 sq. ft.
Total evaporative	2 451 sq. ft.
Superheater	612 sq. ft.
Grate area	48.5 sq. ft.
Boiler pressure	250 lb./sq. in.
Tractive effort	33 495 lb.
Adhesion factor	4.34
Weight of engine in working order	97 tons 18 cwt.
Weight of engine and tender in working order	151 tons 4 cwt.

[625 .232 (42) & 625 .234 (42)]

Window construction for air-conditioned vehicles.

Hermetically sealed glasses; humidity is removed by mechanical or chemical means.

With the application of air-conditioning to railway vehicles, it is necessary to give particular attention to the insulation of the bodysides, roof and floor. Double-glazed fixed windows are normally used, but for emergency, one or two opening windows may be fitted. It is important that condensation should not form on the inner faces of the double-glazed fixed windows.

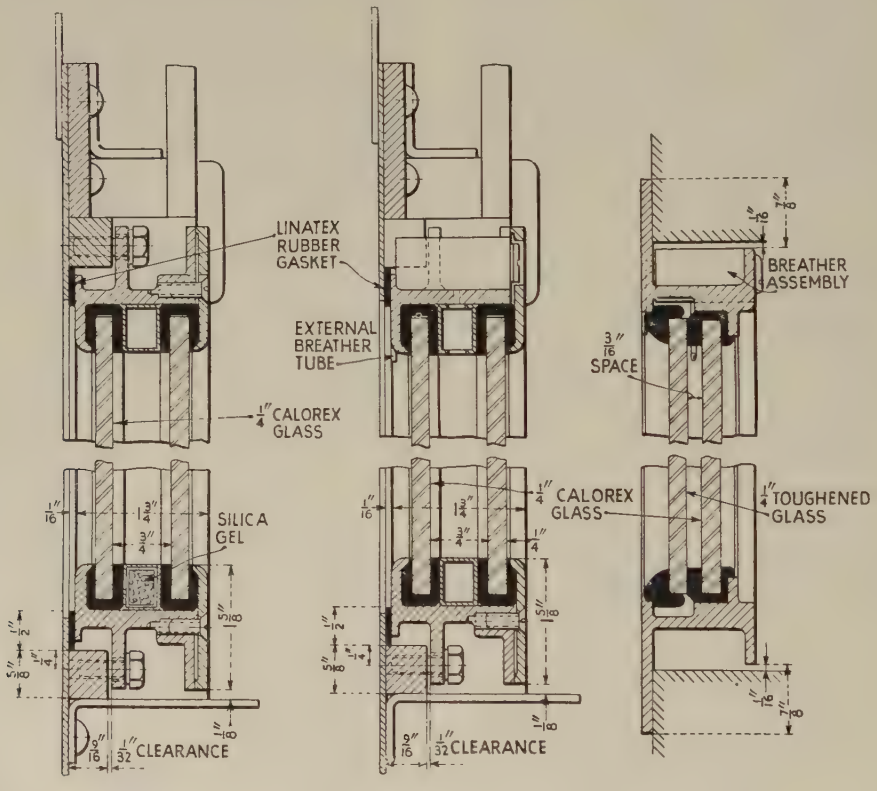


FIG. 1 FIG. 2 FIG. 3

Fig. 1. — Design for air-conditioned rolling stock using hygroscopic material
Fig. 2. — Similar design to figure 1, but using a breather apparatus.
Fig. 3. — A more recent application using Beclatite rubber and toughened glass.

Dehydration.

Various designs have been adopted, such as hinged inner glasses, but the more recent method is virtually to seal the two glasses hermetically, and to remove the humidity from the air space by mechanical or chemical means. An example of a window with chemical dehydration is the Beclawat Cyclone type, a sectional drawing of which is shown in figure 1.

This window is provided with hygroscopic material in the form of silica-gel or activated alumina, held in position with copper gauze wire containers which are fitted into a tube running along the full width of the bottom member of the window. In this arrangement the space between the glasses allows for sufficient of this medium, not only to absorb the moisture from the air space, but also to provide a margin of safety. From a sound insulation viewpoint, the greater the space the better; where thermal efficiency is concerned a ¾-in. space approaches the optimum. This type of window has been fitted to air-conditioned stock on the Iraqi and Italian State Railways and the Egyptian Republic Railways.

Breathing apparatus.

A similar type of window by the same makers, and which has, it is said, been used in North America, is shown in figure 2, but instead of the hygroscopic material between the glass a breathing apparatus is fitted. This involves the use of a filter, and a small tube leading from the space between the glass to the outside of the coach. The design is suitable for use on air-conditioned rolling stock operating over a wide range of temperatures.

A later application is provided in the simpler type of window shown in figure 3. In this case the space between the glass can be reduced, and the glass may be fitted with Beclatite patent rubber. In this way the renewal of the glass is a simple matter, and the cost of the frame is very much less than other types. They can be supplied with varying types of fixings such as shown in figure 1, or with outside or inside flanges. Windows of this type are being supplied to the Mozambique Railways.

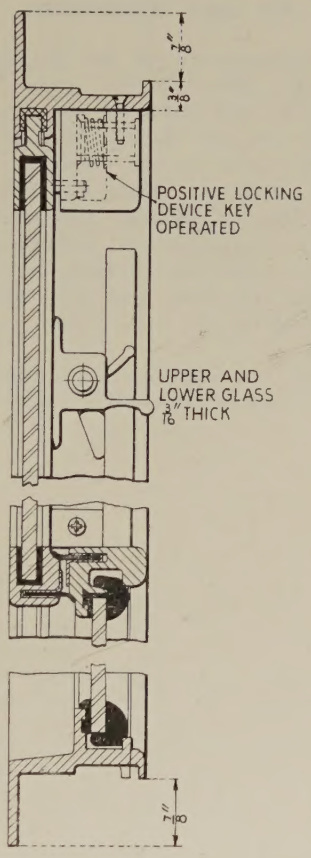


Fig. 4. — Arrangement of Beclawat Chinook halfdrop window.

The principle on which the breather type windows operate is very simple Any variation in outside temperature will cause the air pressure between the outside of the vehicle and the air space between the two glasses to vary. Similarly, pressure differences can also result

from travelling in varying altitudes. It therefore follows that pressure differences will cause air either to be drawn into, or expelled from, the air space. Since the glasses are sealed, the flow of air must take place through the breather tube.

Air space temperature.

The temperature of the air space between the glasses is the mean between the outside and inside of the car, and in cold weather any outside cold air drawn into the space cannot condense on the warmer surfaces between the glasses, but nevertheless, on reaching this warmer air space it is capable of absorbing more moisture. Also, any warmer air expelled from the air space into the colder outside temperature will deposit moisture outside.

In this way condensation cannot occur between the glasses when colder air is being drawn from the outside through the breather. Should the breather be on the inside the reverse would occur, since the warm air of the car entering the colder air space would deposit its excess moisture when cooling. In warmer weather the inside temperature is likely to be lower than the outside, but, since good air-conditioning practice limits this temperature difference to about 10° F., the difference is not sufficient to cause condensation when breathing in air from the outside. In tropical climates it is advisable for one of the glasses of the double-glazed fixed windows to be of the heat absorbing type such as Calorex plate glass or Pilkington Antisun glass. A suitable matching emergency window is the Beclawat Chinook half-drop type, a sectional drawing of which is shown in figure 4. It is provided with a lock at the top to suit a standard carriage key, so that it can be operated only by the train staff.

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